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Transactions of the American Orthopaedic Association

Volume I of *The Journal* (then called the *American Journal of Orthopaedic Surgery*), published in 1903, took the place of Volume XVI of the Transactions of the American Orthopaedic Association. From time to time *The Journal* has requests for copies of the volumes issued prior to that date. Any reader having copies of these earlier volumes, which he is willing to dispose of, is requested to write to *The Journal*, indicating volumes available and selling price.

ADDRESS

THE EDITOR

THE JOURNAL OF BONE AND JOINT SURGERY

8 THE FENWAY, BOSTON, MASSACHUSETTS

VOL. XIX, NO. 1 JANUARY, 1937 Old Series Vol. XXXV, No. 1

The Journal of
Bone and Joint Surgery

TIBIA VARA

Osteochondrosis Deformans Tibiae

BY W. P. BLOUNT, M.D., MILWAUKEE, WISCONSIN

From The Marquette University Medical School, the Children's Hospital, and the Columbia Hospital, Milwaukee

During the past twenty years the medical journals have been deluged with articles on "osteochondritis" at this or that epiphysis. Mention has frequently been made of involvement of the proximal end of the femur, of the tonguelike projection of the proximal tibial epiphysis, of the tubercle of the calcaneum, and of the secondary epiphyses of the vertebrae. Abnormal development of almost every epiphysis in the body has been recorded and will be found if a careful search is made. Buchman has mentioned a number of examples. To his list might be added Thiemann's disease of the phalanges [48], Madelung's deformity of the distal end of the radius [35], and an osteochondral lesion of the ischiopubic hiatus [2].

Erlacher reported a case in 1922 in which there was involvement of the medial half of the left proximal tibial epiphysis. In the same year McCurdy reproduced the roentgenograms of a typical bilateral tibia vara and labeled the condition Perthes' disease, but did not mention the case further. In 1929 Lewin described a similar case of Ritter's (Fig. 1). A few more isolated examples had been reported when in 1930 Lülsdorf collected five from the literature and added three of his own. The writer has found six others before that time and nine since then, which are reported with thirteen new ones.

The condition has been variously designated as rickets, chondrodysplasia, a growth disturbance, an unusual epiphyseal change, an epiphyseal defect, osteitis of the upper end of the tibia, and as an unknown disease. Lülsdorf called it "epiphysitis tibiae deformans". It is not an inflammation, however, and, in accordance with the more recent usage, the name should not contain the suffix "itis". It is not limited to the epiphysis, but is an abnormality of growth of the metaphysis, epiphyseal cartilage, and osseous center of the epiphysis. The name should imply

TABLE I

SUMMARY OF UNPUBLISHED CASES

Case No.	Initials	Sex	Age: At Onset (*Years*)	Age: When Seen (*Years*)	Side	Type *	Deformity	Roentgenographic Findings	Treatment	Age at Operation (*Years*)	Recurrence	Remarks
1	J. H.	Female	1	3½	Both	I	Varus { Right, 25° Left, 20°	Sloping medial epiphyses with beaklike metaphyses.	Bilateral osteotomy, July 19, 1932.	4	No	Extreme deformity necessitated operation.
2	G. M.	Female	11	12	Left	A	Varus: 15° Short: 1.5 cm.	Irregularity of epiphysis medially.	Osteotomy, June 25, 1926.	12½	Yes	Fall followed at once by a limp.
3	E. C.	Male	1	5	Left	I	Varus: 25° Short: 2.5 cm.	Lacy enlargement of metaphysis medially. Angulation below.	Operation advised.			Inward rotation of left leg on thigh.
4	F. S.	Female	2	29	Left	I	Varus: 35°	Marked bowing of proximal tibia. Thick medial cortex.	Operation advised, but refused.			Rotation, subluxation, deformity, and pain.
5	B. B.	Female	11	12	Left	A	Varus: 12° Short: 7 mm.	Narrow dense epiphysis medially with early closure.	Osteotomy, March 9, 1934.	14	No	Symptoms of strain relieved conservatively.
6	N. J.	Female	1	2½	Both	I	Varus: 15°	Sloping medial epiphyses with beaklike metaphyses.	Medical.			Overweight. Eczema during fourth to fifth months.
7	M. S.	Female	2	7	Right	I	Varus: 22° Short: 1.8 cm.	Abrupt angulation below epiphysis. Irregular epiphysis medially.	Osteotomy, June 24, 1935.	9	Slight	Rapid increase of deformity at six years.
8	H. P.	Female	2	11½	Left	I	Varus: 15° Short: 3 cm.	Abrupt angulation below epiphysis. Irregular epiphysis medially.	Osteotomy and epiphyseal arrest, March 2, 1936.	11½	No	Pain and increased bowing appeared at eleven.
9	S. A. C.	Female	1	4	Left	I	Varus: 12°	Sloping tibial epiphysis. Beaklike metaphysis.	Osteotomy, January 8, 1936.	4	No	Similar involvement of right without excessive angulation.
10	H. C.	Female	1	1	Both	I	Varus	Sloping tibial epiphyses. Beaklike metaphyses.	Braces. Operation refused.			Increase of deformity during observation.
11	A. J.	Male	1	2	Right	I	Varus: 15°	Beaklike metaphysis. Irregular density.	Observation.			Bowing of left disappeared.
12	R. W.	Male	13	21	Both	A	Varus { Right, 10° Left, 15° Shortening	Abrupt angulation below tibial heads. Epiphyses closed.	Bilateral osteotomy, April 14, 1936.	21	No	Pain and transient locking, both knees.
13	M. B.	Female	7	9	Left	A	Varus: 20° Short: 1 cm.	Narrow epiphysis. Projecting metaphysis. Abrupt angulation.				Onset following acute respiratory disease.

* I = Infantile type. Onset at the time when the child begins to walk.
A = Adolescent type. Onset at the second rapid-growth period, from eleven to thirteen years (occasionally at six or seven years).

the involvement of both cartilage and bone. These cases are similar to the other "osteochondrotrophopathies". The term is accurately descriptive of the lesion, but is too unwieldy for ordinary use. The more inclusive term "osteochondrosis" has been used by the writer. It finds a parallel in the term "arthrosis" which has come into general use in Europe. Lülsdorf's designation "deformans" has been retained to differentiate this lesion from Osgood-Schlatter disease, in which there is no gross alteration of form. "Tibia vara" is a satisfactory anatomical designation, in keeping with the terms "coxa plana" and "genu varum".

Fig. 1

Case 22. Aged seven years. Left knee.

Although the condition has received scant attention, it is not nearly so uncommon as one would suppose. It deserves more general recognition and differentiation from other lesions causing deformity at the knee. Thirteen new cases are presented in tabular form in Table I. Representative summaries of a few of them will suffice to characterize the entity.

TYPE I

Infantile Tibia Vara

Case 1. J. H., a white female, three and one-half years old, was brought in by her parents because of extreme bowing of both legs, first noted when she began to walk. Adequate cod-liver oil and orange juice had been given.

There was marked angulation of both legs into bow-leg and back-knee just below the tibial head (Fig. 2). There was moderate in-toeing, but no other evidence of rickets. The bones were hard and inelastic.

The roentgenograms (Fig. 3) showed that both proximal tibial epiphyses were deficient medially where they sloped to sharp edges instead of to rounded margins. There were beaklike medial projections of the metaphyses, at the tips of which there were small cystlike areas of rarefaction. The contours of the soft tissues suggested bulblike extension of the cartilage even beyond these points. The medial cortex was much increased in thickness on both sides. Except for the angulation mentioned, the bones of the legs were straight.

Because of the extreme deformity, on July 19, 1932, bilateral osteotomy was performed by "slivering" the shafts obliquely with overcorrection of about 10 degrees on both sides.

Fig. 2

Case 1. J. H., aged three and a half years. Before operation.

A piece of the "beak" on the right was removed for microscopic study. The report of Dr. G. H. Hansmann of Columbia Hospital was as follows: "On microscopic examination a marked distortion of trabeculae of bone at the point of junction with cartilage was observed. [See Figure 4.] The distortion seemed to be a bending of these trabeculae all in the same direction. The distortion of the epiphyseal cartilage with a bending of the bone trabeculae had pushed the periosteum outward and it had arched over the bone and cartilage. There were spicules of bone on the outer surface of the cartilage, which appeared to be independent of the bone trabeculae at the epiphyseal line. It may be that in this marked distortion osteoblasts were carried out around the cartilage and were responsible for this bone formation. The cartilage had softened in places and granulation tissue had invaded some of the softened areas, while others appeared as holes in the cartilage. [See Figure 5.] There were islands of cartilage and calcium deposit which were probably calcified cartilage in the center portion of bone trabeculae, quite remote from the epiphyseal line. That is, bone had been laid down about this cartilage without replacing it in the ossification of the trabeculae. Some of the trabeculae revealed marked osteoblastic activity about them. Diagnoses: Defective osteogenesis; mechanical deformity of bone."

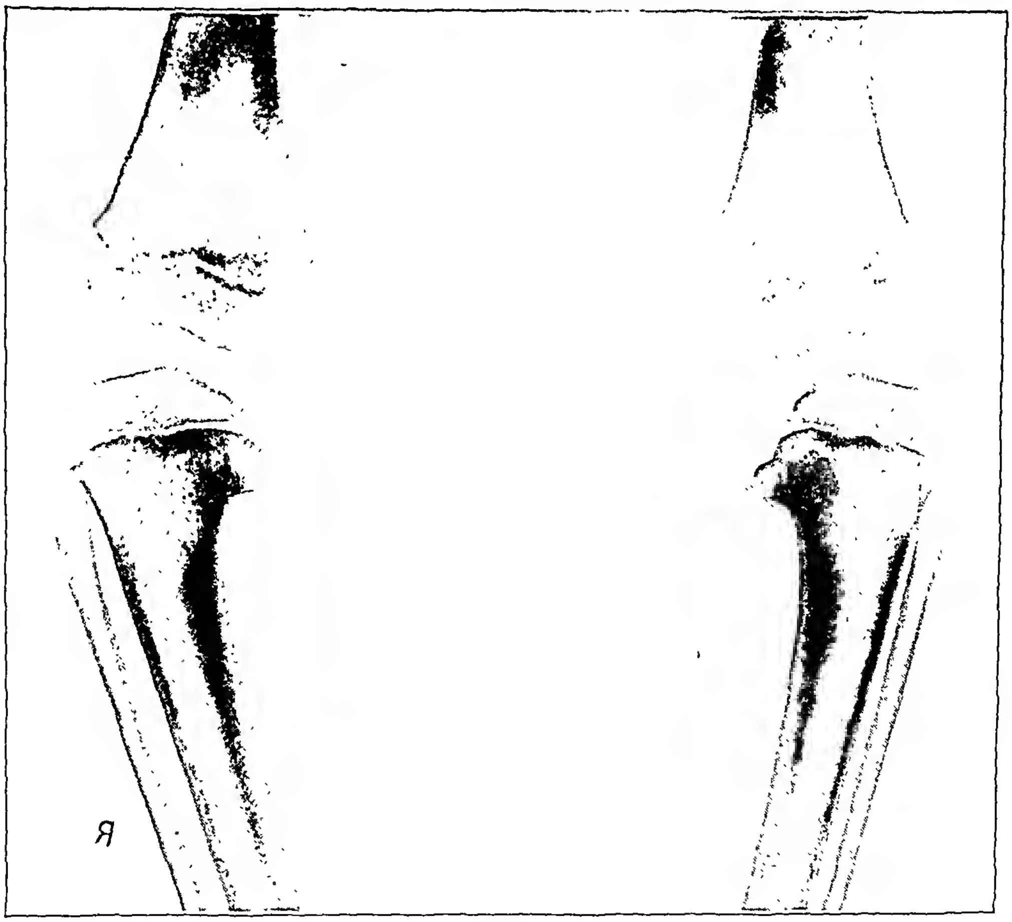


Fig. 3

Case 1. J. H., aged three and one-half years. Roentgenogram before operation.

A spica cast was applied and allowed to remain for seven weeks; following this, braces were worn for four months. A roentgenogram (Fig. 6) shows overcorrection. Figure 7 shows the appearance three months later. There was no recurrence at the end of four years.

FIG. 4

Case 1. J. H. Photomicrograph of the metaphysis, showing the distorted bone trabeculae and focal areas of marked osteogenesis.

FIG. 5

Case 1. J. H. Photomicrograph of metaphysis, showing the softened cartilage, calcification, and islands of cartilage cells in the trabeculae and bending of the bone trabeculae.

Fig. 6

Case 1. J. H., aged four years. Roentgenogram after operation.

Case 4. F. S., a white female, aged twenty-nine, complained of bowing of the left leg and pain in the left knee. She had been a strong, healthy child and there was no history of rickets. There were no bone diseases or deformities in the family. At two years of age, both legs had become markedly bowed. Braces had been worn and the right leg had gradually straightened. Even though a brace had been worn on the left leg until the patient was fourteen years of age, the bowing persisted. There had been pain in the left knee for three years.

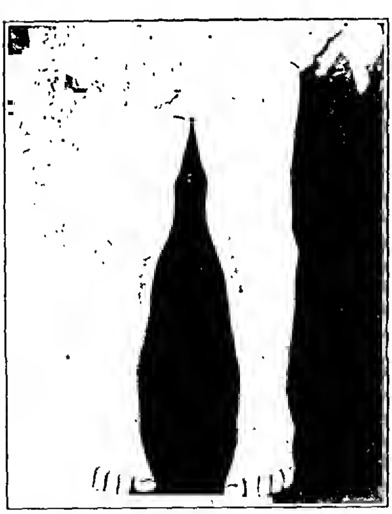


Fig. 7

Case 1. J. H., aged four years. Three months after operation.

There was angulation of the left leg of 35 degrees with the apex laterally and at the upper end of the tibia. The deformity was increased during weight-bearing. The tibia was rotated outward on the femur 25 degrees with slight subluxation.

A roentgenogram of the left leg (Fig. 8) showed extreme bowing of the upper end of the left tibia with superimposition of the fibula. The shaft of the tibia was greatly increased in width, and the medial cortex was three times as thick as the lateral. Osteotomy was advised, but was refused.

Case 7. M. S., a white female, seven years old,

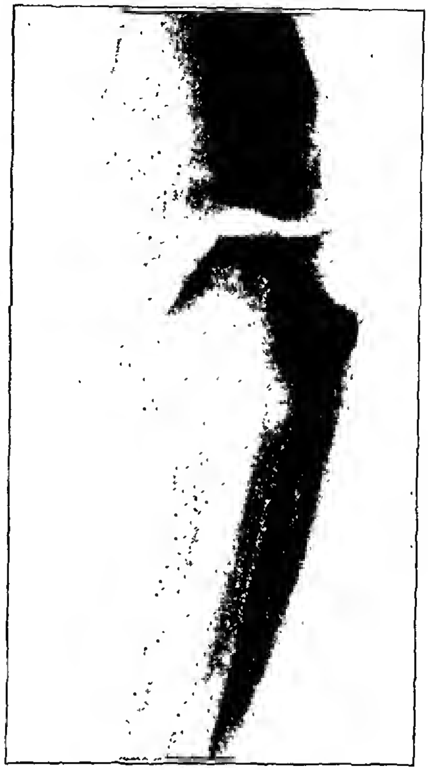


Fig. 8

Fig. 8

Case 4. F. S., aged twenty-nine years. Left knee. Onset of bowing in infancy.

was brought to the Milwaukee Children's Hospital on August 14, 1933 because of bowing of the right leg. She had been delivered by instruments at term. No cod-liver oil had been given. Both legs were bowed at fourteen months when she started to walk. They had straightened out somewhat at four years. At six the bowing had become much exaggerated on the right. The family history was negative.

There was abrupt bowing just below the right knee, but no other evidence of active rickets. The right leg was one centimeter shorter than the left. Roentgenograms and a tracing were made, and a brace was supplied. In spite of this, the deformity increased steadily in the next two years (Fig. 9). There was abnormal mobility of the right knee on medial strain, with angulation and shortening of one and eight-tenths centimeters. A roentgenogram (Fig. 10), taken on April 4, 1935, showed an angulation of the right tibia of 22 degrees with the apex laterally. The epiphyseal line was irregular in outline and narrower than on the left, and the medial tibial cortex was thicker.

An osteotomy was performed on June 24, 1935, because of the increasing disability. The bowing on the right was overcorrected (Fig. 11) and the knock-knee persisted for several months. After one year, a slight recurrence of the angulation made the legs straight (Fig. 12).

Case 8. H. P., a white female, aged eleven and one-half years, of Greek parentage, was brought to the University of Chicago Clinics on February 17, 1936, because of bowing of the left leg. This had first been noted by the parents when the patient was two years of age. There had been only slight improvement as she grew older. Two years before admission, there had been pain on the medial side of the left knee, which had lasted one week. Nine months before admission, there had been an increase of the bowing and of the limp. There was nothing significant in the past or family history.

The patient walked with a considerable limp on the left. There was angulation of the left tibia, with the apex laterally, just below the knee joint with marked prominence of the fibular head (Fig. 13).

A roentgenogram of the left tibia (Fig. 15) showed irregularity and broadening of the proximal epiphyseal line medially. The distinction between the cartilage and the bone was less marked. Below the epiphysis

Fig. 9

Case 7. M. S., aged nine years. Before operation.

there was an abrupt angulation inward of 15 degrees with the apex laterally. Teleoroentgenograms showed a shortening of three centimeters on the left.

Overcorrection was obtained by an osteotomy on March 2, 1936. This was combined with epiphyseal-diaphyseal fusion of the proximal tibial and fibular epiphyses on the left. There appeared to be bony fusion between the epiphysis and the diaphysis of the left tibia medially. Epiphyseal fusion was similarly performed on the right. Good overcorrection was obtained (Fig. 16). There was no recurrence at the end of six months (Fig. 14).

TYPE A

Adolescent Tibia Vara

Case 2. G. M., a white female, twelve years of age, had fallen from a swing in June 1925, abrading the left knee. The wound had healed in four weeks, but she had limped for several weeks longer. Three months later the mother had noticed that the leg was becoming bowed; during the next six months the angulation became worse. The patient had limped for the two weeks previous to examination on January 27, 1926.

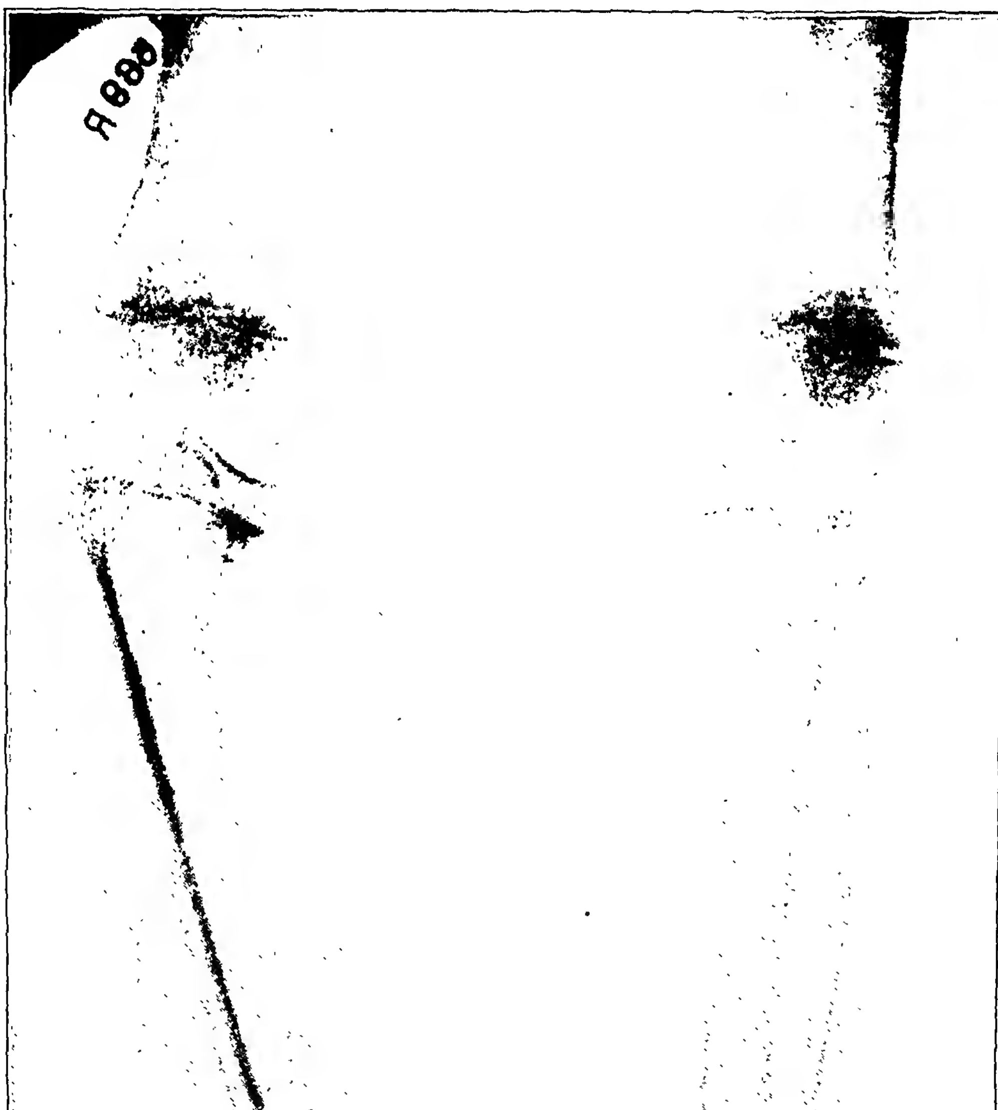


Fig. 10

Case 7. M. S., aged nine years. Roentgenogram before operation.

Fig. 11
Case 7. M. S., aged nine years. Roentgenogram of right tibia after operation.

There was no swelling, tenderness, or increased local temperature about the knee. Motions were normal. The left leg was bowed just below the knee, so that the knees were separated by two centimeters when the malleoli were together. The right tibia was thirty-two centimeters in length; the left tibia, thirty and six-tenths centimeters.

A roentgenogram (Fig. 24-A) showed an irregularity of contour of the left proximal tibial epiphyseal line with abrupt angulation at the metaphysis with the apex laterally. Except for the modified pattern of the lines of stress, there was no abnormality of the bone.

A brace relieved the pain and was worn for six months. An osteotomy was performed on June 25, 1926, at twelve and one-half years of age. After eight weeks, the cast was replaced by a brace. The legs were symmetrical. The length of the right leg was seventy-nine and four-tenths centimeters; that of the left, seventy-six and six-tenths centimeters. In a telephone conversation two years later, it was learned that the deformity had partially recurred.

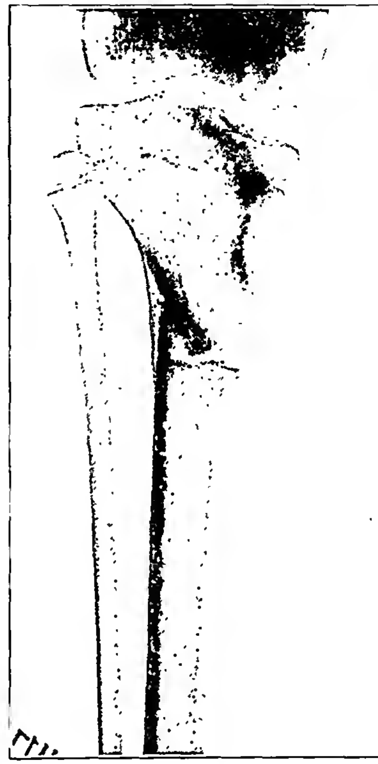


Fig. 11

Case 5. B. B., a white female, was twelve years old when first seen on November 3, 1932, because of a limp on the left, and aching of the left foot and knee. The symptoms had first appeared a year and one-half previously, following a sprain of the left ankle. In the spring of 1932, bowing of the left leg had been observed. Just before the examination, the symptoms became worse.

A well-nourished, athletic girl, the patient was normal in every way except for the left leg, which was bowed abruptly just below the knee. The symptoms were largely due to the relative flat-foot and foot strain on the left. There was increased mobility of the knee joint on medial strain and slight bilateral recurvatum. The length of the right leg was eighty-five and three-tenths centimeters; that of the left, eighty-four centimeters. The difference was greater on weight-bearing. Symptomatic treatment relieved the aching, and the limp disappeared.

A roentgenogram of both knees (Fig. 17) showed an angulation of 12 degrees with the apex laterally at the proximal end of the left tibia. The epiphyseal line was more nearly closed than on the right and was irregular in contour medially. These changes were not striking, and the bones were otherwise normal.

When the patient was fourteen years of age, an osteotomy of the left tibia was performed, for cosmetic

Fig. 12
Case 7. M. S., aged ten years. Six months after operation.

reasons, on March 9, 1934. A plaster spica was applied with the leg in a position of overcorrection. A crutch was added a few days later. In this peg-leg cast [6], the patient walked about during her convalescence. Two years later there had been no recurrence (Fig. 18). The legs measured the same length, and a slight left total scoliosis had entirely disappeared. The slight increase in mobility of the knee joint on medial strain was the only residuum, but this caused no disability.

Fig. 13

Case 8. H. P., aged eleven and one-half years. Before operation.

Case 13. M. B., a white female, nine years old, gave a history of a bowleg on the left at seven years of age, shortly after a severe respiratory infection. There had been a gradual increase of the deformity. Pain had appeared over the head of the left fibula after long walks. There had

Fig. 14

Case 8. H. P., aged twelve years. After operation.

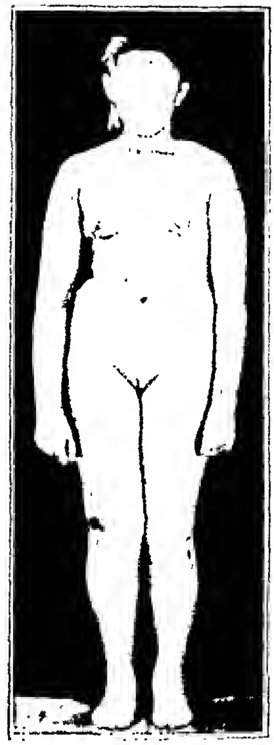


Fig. 14

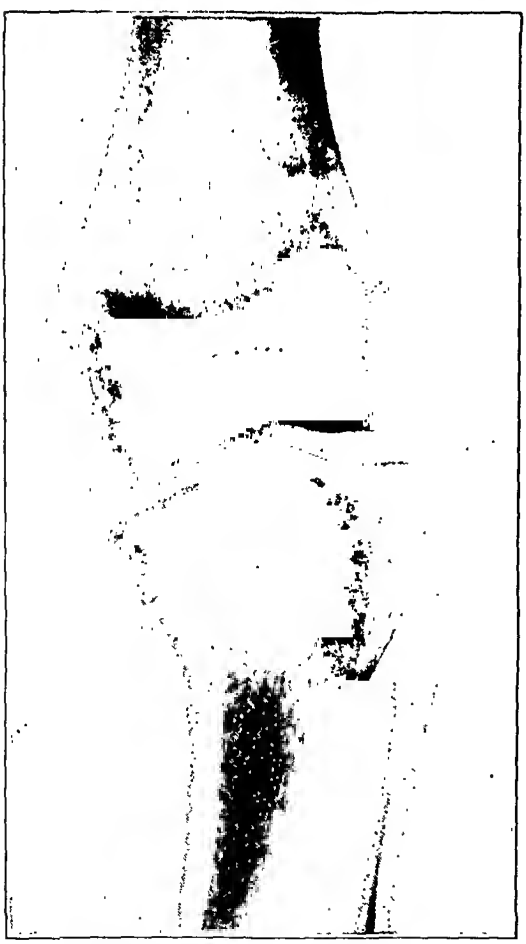


Fig. 15

Case 8. H. P., aged eleven and one-half years. Left knee before operation.

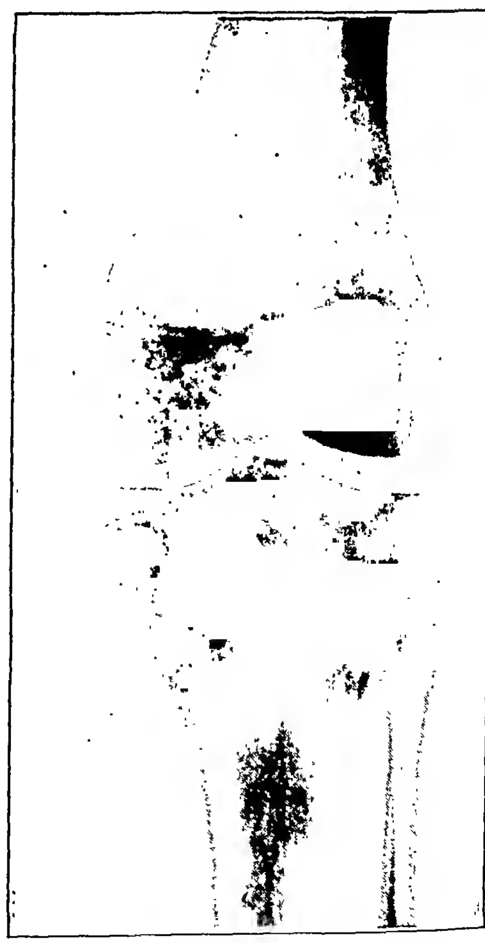


Fig. 16

Case 8. H. P., aged eleven and one-half years. Roentgenogram after osteotomy and epiphyseal fusion.

been some bowing of the right leg just prior to examination. There was nothing of importance in the past or family history.

The examination was negative except for the bow leg on the left (Figs. 19-A and 19-B). There was marked angulation just below the knee, but the tibia was straight distal to this point. The same was true of the right leg to a lesser degree. The left leg was one centimeter shorter than the right. The reflexes and circulation were normal.

In the roentgenogram (Fig. 20) the height of the proximal tibial epiphyses was less medially than normal. On the left, the medial margin was rounded off and was narrower than the lateral margin. The metaphysis projected in the form of a sharp beak. There was abrupt angulation of the shaft of the tibia of 20 degrees with the apex medially. There was no diminution of the joint interval, and no gross irregularity of the epiphyseal line.

The salient features in the cases from the literature have been tabulated for the sake of brevity in Table II.

For comparison, it was thought advisable to present tracings of the roentgenograms of the new cases and tracings of those from the literature. Only the anteroposterior views have been used because, where available, the lateral added little to our knowledge. The tracings (Figs. 21 to 25 inclusive) have been grouped according to similarity of appearance.

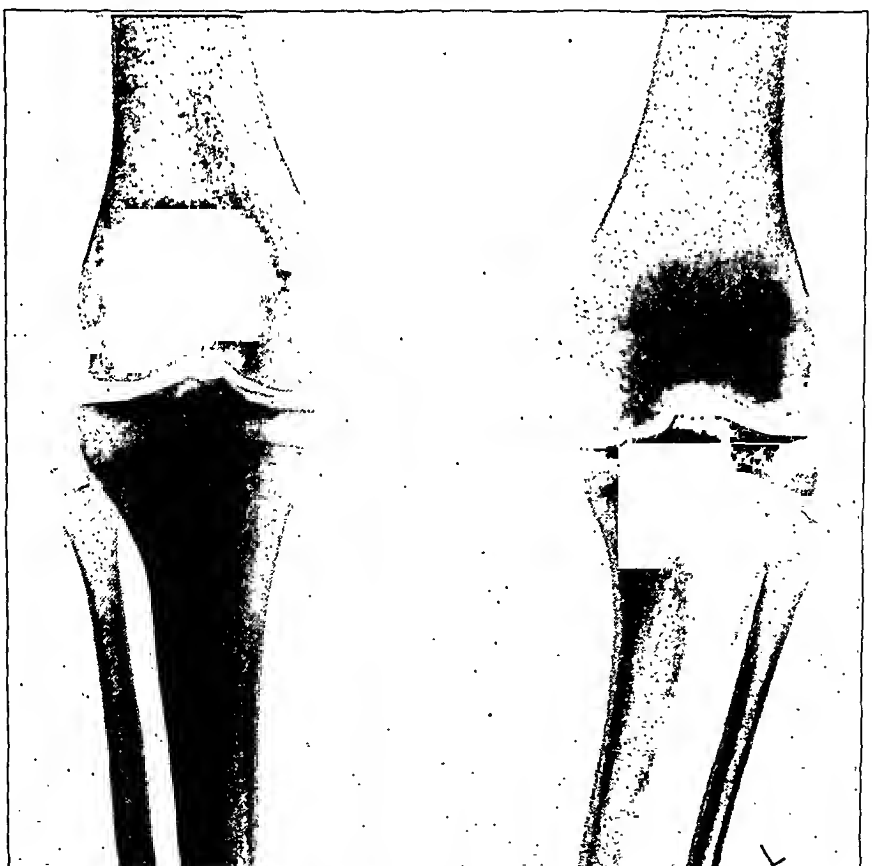


Fig. 17

Case 5. B. B., aged twelve years.

THE INFANTILE GROUP

The tracings in Figures 21, 22, and 23 are similar in appearance and suggest a common etiology. Cases 19, 21, and 27, however, must be excluded because of the history of late onset and placed in the adolescent group. Cases 4, 7, and 26 (Fig. 24) are quite different in appearance, but must be included with the first group because of the onset of bowing in infancy.

Twenty cases are of the infantile type. There were seventeen females and two males and in one case the sex was not recorded. In each case there was a history of normal development to the age of from one to two years, usually with some overweight. Then the exaggerated physiological bow-leg [7], instead of developing gradually into the normal knock-knee, became more marked. This increase in deformity was bilateral in nine cases, on the left side only in seven, and on the right side only in four. Rickets could be ruled out in most cases and was not prominent in any case. No likely etiological factors were suggested by the history or by the associated findings.

Roentgenograms were so uniform in appearance as to suggest a common cause. Figure 26-B shows diagrammatically the abrupt angulation (A) just below the proximal tibial epiphysis, the medially expanded, some-

Fig. 18

Case 5. B. B., aged sixteen years. Two years after operation.

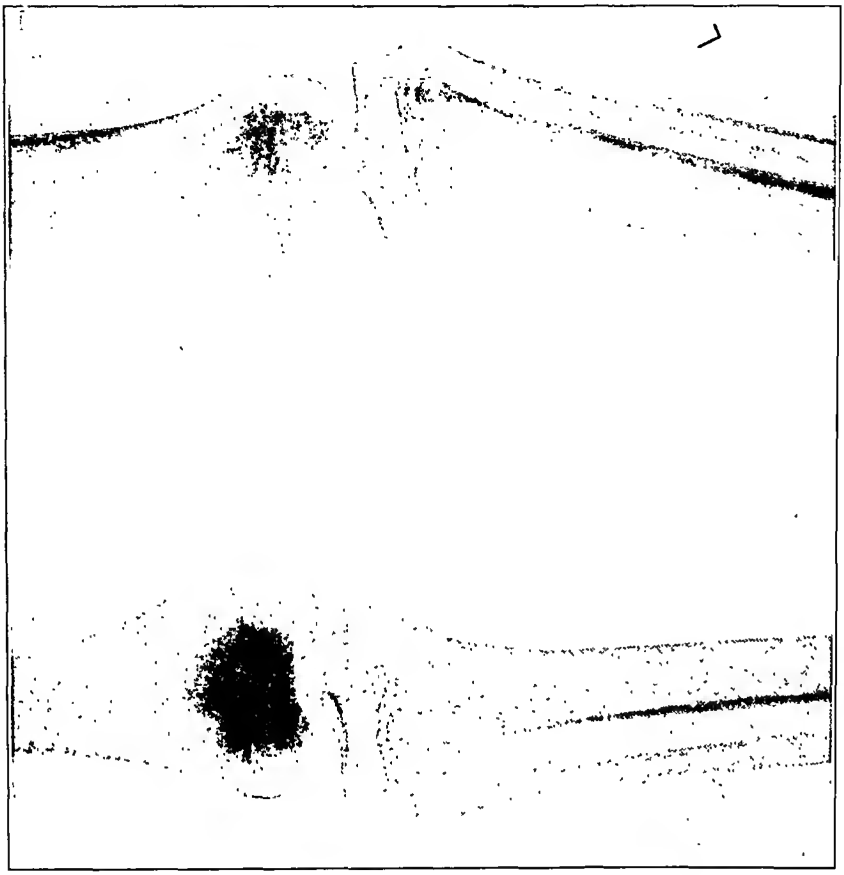


FIG. 20
Case 13. M. B., aged nine years.

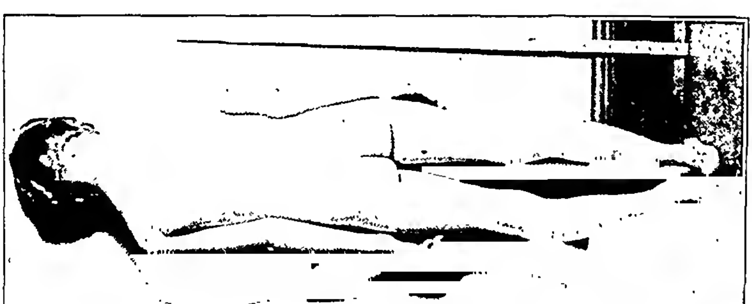


FIG. 19-B

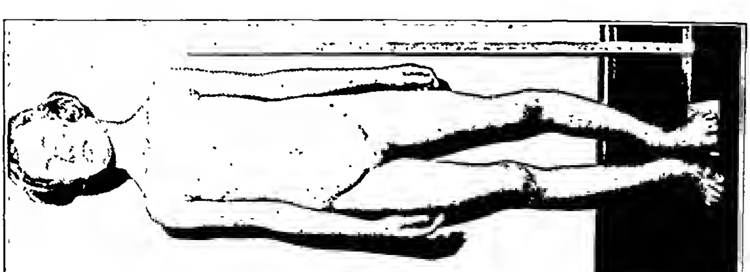


FIG. 19-A
Case 13. M. B., aged nine years.

TABLE II

SUMMARY OF CASES FROM THE LITERATURE

Case No.	Year	Writer	Country	Sex	Age: At Onset (Years)	Age: When Seen (Years)	Side	Type *	Deformity
14	1899	Kirmisson	France	Female	13	20	Left	X	Varus
15	1922	Erlacher	Austria	Female	1½	2½	Left	I	Varus: 30°
16	1922	Valentin	Germany	Female	4	7	Left	X	Varus Short: 2 cm.
17	1922	McCurdy	United States				Both	I	Varus
18	1924	Mau	Germany	Female	Birth	6	Right	I	Varus: 15° Short: 1 cm.
19	1928	Langenskiöld	Finland	Male	11	11	Right	A	Varus
20	1928	Nilsonne (Case 1)	Sweden	Female		7	Both	I	Varus
21	1928	Nilsonne (Case 2)	Sweden	Male	7	8	Left	A	Varus
22	1929	Lewin and Ritter	United States	Female	Birth	7	Left	I	Varus: 20°
23	1929	Rall (Case 1)	Germany	Female	Birth	8	Both	I	Varus
24	1930	Lülsdorf (Case 1)	Germany	Female	8	9	Left	A	Varus: 20° Short: 2 cm.
25	1930	Lülsdorf (Case 2)	Germany	Female	11	12	Left	A	Varus Short: 2 cm.
26	1930	Lülsdorf (Case 3)	Germany	Female	Birth (?)	10	Left	I	Varus
27	1930	Rocher and Roudil	France	Female	6	8	Right	A	Varus: 15° Short: 1 cm.
28	1932	Maselli (Case 1)	Italy	Male	3	13	Right	X	Valgus Short: 4 cm.
29	1932	Maselli (Case 2)	Italy	Male	13	17	Right	X	Valgus Short: 5 cm.
30	1933	Gickler (Case 1)	Germany	Male	8	10	Left	X	Short: 2 cm.
31	1933	Gickler (Case 2)	Germany	Male			Right	X	Short: 2 cm.
32	1933	Van Gelderen	Holland	Female	5	8	Left	X	Short: 1½ cm. Varus
33	1934	Rall (Case 2)	Germany	Female	1	2	Both	I	Varus
34	1936	Sloane, Sloane, and Gold (Case 1)	United States	Female	2	6	Both	I	Varus
35	1936	Sloane, Sloane, and Gold (Case 2)	United States	Female	Birth	7	Both	I	Varus
36	1936	Sloane, Sloane, and Gold (Case 3)	United States	Female	Birth	4	Right	I	Varus

*I = Infantile type. Onset at the time when the child begins to walk.
A = Adolescent type. Onset at the second rapid-growth period, from eleven to thirteen years (occasionally at six or seven years).
X = Cases which have been included by other writers, but in which the affection appears to be obviously econdary or of a different character.

SUMMARY OF CASES FROM THE LITERATURE

Suggested Etiology	Roentgenographic Findings	Treatment	Age at Operation (*Years*)	Recurrence	Remarks
Late rickets	Angulation below proximal tibial epiphysis.				Also right genu valgum and right dorsal scoliosis.
Congenitally predisposed	Epiphysis deficient medially; beaklike rarefied metaphysis.	Curved osteotomy	2½	No	Father had arthritis deformans of left hip at twenty-seven.
Chronic osteomyelitis	Epiphysis patchy and deficient medially.	Osteotomy in 1921	7		Pain and swelling in right ankle and left middle finger.
Perthes-like	Angulation with beaklike medial metaphysis.				No discussion. Only x-ray presented.
Cartilaginous exostoses	Sloping epiphysis medially and beaklike metaphysis.	Osteotomy in 1923	6		No other deformity of skeleton.
Perthes-like	Broad, hazy epiphyseal line medially with abrupt angulation.	Curved osteotomy suggested			Gradual narrowing of epiphyseal line in five years.
Unclassified growth disturbance	Sloping epiphysis medially; beaklike metaphysis.	Osteotomy in December 1926	7		Entire skeleton otherwise negative to x-ray.
	Low epiphysis medially with enlarged metaphysis.				Destructive process in left hip preceded that of knee by three years.
Perthes-like	Sloping epiphysis, obscured line, and beaklike metaphysis.	Osteotomy	7	Yes	Both legs very bowed until four years.
Perthes-like	Sloping epiphysis medially with beaklike metaphysis.	Osteotomy in January 1928 Osteotomy in September 1928	8	Yes	Not at first overcorrected.
Inflammatory process of epiphysis	Irregular defect of medial epiphyseal line.				No other symptoms, but bowing and limp.
	Epiphyseal line medially irregular in shape and density.				Intermittent attacks of pain.
	Rarefaction and irregularity of epiphyseal line medially.	Osteotomy in April 1925 Osteotomy in July 1927	11 13	Yes Yes	Bilateral at first. More marked on left.
Congenital hypoplasia	Agenesis of medial epiphysis with beaklike metaphysis.	Osteotomy in January 1928 Osteotomy in November 1929	8 10	Yes	Rapid recurrence after first correction.
Infection	Localized increased density of epiphyseal line.	Wedged cast			Smallpox at thirteen months.
	Epiphyseal line wide on medial side.	Medical			Typhoid fever preceded the onset.
Vitium primae formationis	Narrow dish-shaped epiphyseal line with irregular epiphysis.				Patella bipartita.
	Marked narrowing of epiphysis medially.				Femoral epiphysis irregular, bipartite patella.
Perthes-like	Epiphyseal line dish-shaped, but not irregular.				Pain when kneeling.
Perthes-like; congenital predisposition	Beaklike recurving metaphysis.				Pain and disability for a few days.
Dyschondroplasia	Sloping fragmented medial epiphysis; beaklike metaphysis.				More marked on the right.
Dyschondroplasia	Sloping medial epiphysis; beaklike metaphysis.	Biopsy			Failure of growth differentiation and ossification of cartilage cells.
Dyschondroplasia	Sloping fragmented medial epiphysis; beaklike metaphysis.				

times irregular epiphyseal line (*B*), the wedge-shaped epiphysis (*C*), and the prominent, beaklike, recurving, medial metaphysis (*D*). Within the beak are the cartilage islands (*E*). Over the bony prominence there is hyaline cartilage and over this the soft parts form an additional enlargement. This may be palpated as a bulbous prominence, but it is not an exostosis as described by Mau and suggested by a hasty look at the roentgenogram.

THE ADOLESCENT GROUP

The nine cases of the second group are typified by Cases 2, 5, 24, and 25 (Fig. 24). The onset was between six and twelve years of age in previously normal children. Cases 14 and 28 (Fig. 25) might be classed with these, but they are not included because of multiplicity of lesions in Case 14 and the occurrence of valgus instead of varus in Case 28. In Cases 2, 5, and 24 (Fig. 24) trauma was a likely exciting cause. Cases 19, 21, and 27 are somewhat similar in roentgenographic appearance to the infantile group, but they must be included here instead because the deformity did not appear during infancy.

Cases 30 and 32 (Fig. 25) are strikingly similar in appearance. The onset at eight and five years respectively associates them as to etiology. The shortening was relatively the same in both. In Case 32 the patient had some pain in the left leg at eight months, but after five weeks her condition was normal again and remained so until five years later, when pain returned and swelling appeared. In Case 30 there is no etiology suggested other than the inevitable trauma of football which was a favorite sport with the boy. Here the presence of a bilateral patella bipartita raised the question of a congenital factor. Case 31 was reported by Gickler as a growth disturbance similar to that of Case 30. The femur is likewise involved, however, and the defective appearance of the adjacent epiphyses has little in common with the other cases. It is the only one in which the epiphyseal line is not disturbed. The association of a patella bipartita suggests a developmental defect of the right knee joint.

The deformity in Case 29 closely followed typhoid fever, and in Case 16 there was pain and swelling of the knee, associated with bone infection elsewhere. These seem to have been secondary lesions.

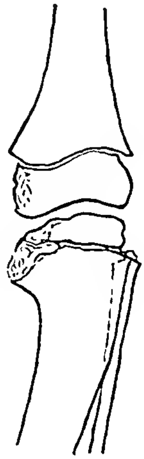
In Case 21 the deformity of the left knee appeared at seven years of age, two years following a destructive lesion of the right acetabulum. The appearance of the two lesions is described as quite different. It seems logical to regard the influence of the hip lesion as mechanical. The relative lengthening of the left leg must have thrown considerable strain on the medial aspect of the left knee. This strain at the age of seven could conceivably be the exciting cause of an epiphyseal disturbance. If the hip lesion was an osteochondromatosis of the ilium, as suggested by Nilsonne, it is possible that both were manifestations of the same process.

ETIOLOGY

Like the blind men, who, in turn, described the elephant as a rope, a

FIGURE 21

TRACINGS OF CASES WITH UNILATERAL INVOLVEMENT AND SIMILAR ROENTGENOGRAPHIC APPEARANCE SUGGESTING EARLY ONSET



Left

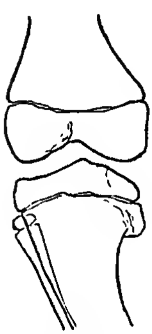
FIG. 21-A
Case 3. Patient E. C.

Left

FIG. 21-B
Case 15. Reported by Erlacher.

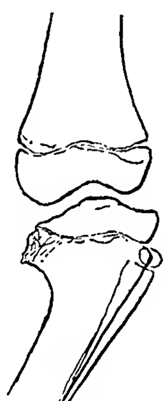
Right

FIG. 21-C
Case 18. Reported by Mau.



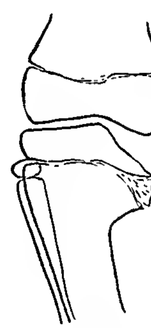
Right

FIG. 21-D
Case 21. Reported by Nilsonne (his Case 2).



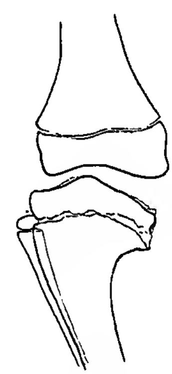
Left

FIG. 21-E
Case 22. Reported by Ritter and Lewin.



Right

FIG. 21-F
Case 27. Reported by Rocher and Roudil.



Right

FIG. 21-G
Case 36. Reported by Sloane, Sloane, and Gold (their Case 3).

tree, a fan, etc., writers disagree as to the etiology. One will see an osteochondral lesion following injury, and for him the general cause is trauma. Another cultures the streptococcus from a biopsy specimen and concludes that infection is the usual cause. We hear embolism, ischaemia, and endocrine dysfunction suggested as explanations. Since Müller described coxa vara in 1888, there has been much speculation as to the cause of such juxta-epiphyseal lesions on the basis of individual experience. Lewin, Buchman, Harbin and Zollinger, and others in recent years have done much to clarify and to correlate our knowledge. The earlier bogy

FIGURE 22

Tracings of Bilateral Infantile Cases and of One Adolescent Case (Fig. 22-D) to Show the Changes in Appearance with Advancing Age

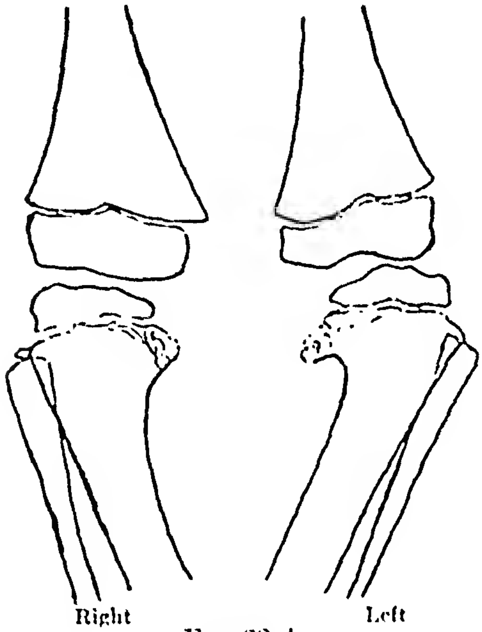


Fig. 22-A
Case 1. Patient J. H.

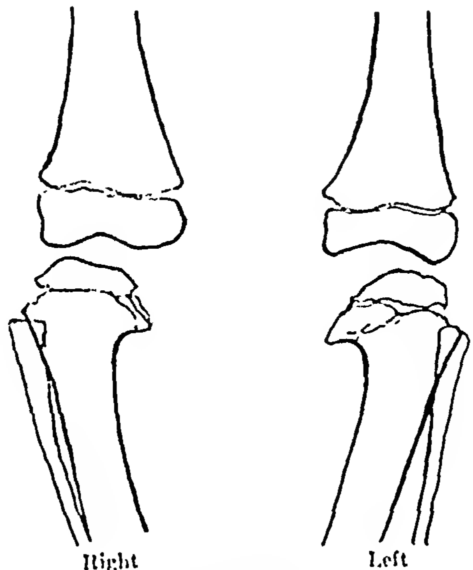


Fig. 22-B
Case 6. Patient N. J.

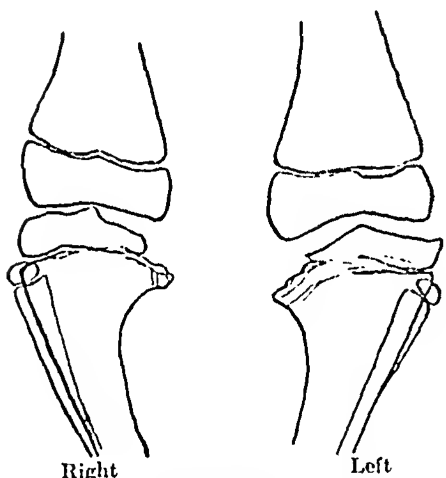


Fig. 22-C
Case 17. Reported by McCurdy.

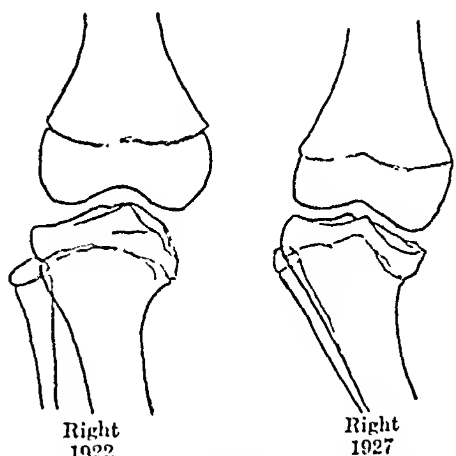


Fig. 22-D
Case 19. Reported by Langenskiöld.

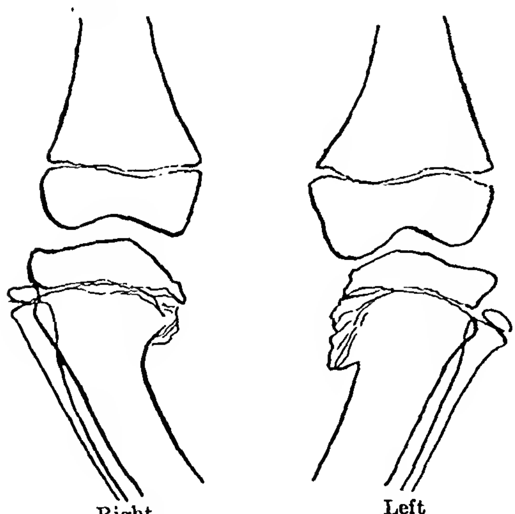


Fig. 22-E
Case 20. Reported by Nilsonne (his Case 1).

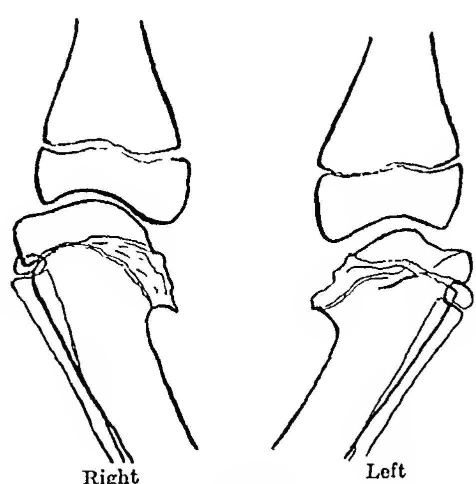


Fig. 22-F
Case 23. Reported by Rall (his Case 1).

FIGURE 23

Tracings of Bilateral Cases of the Infantile Type

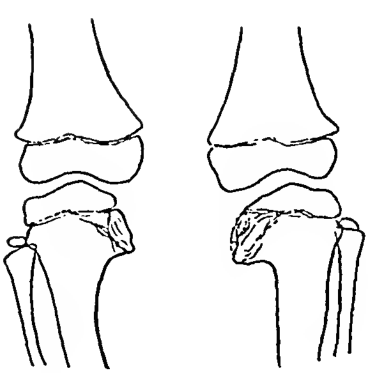


Fig. 23-A
Case 9. Patient S. A. C.

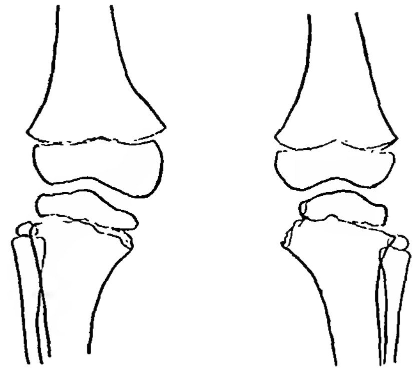


Fig. 23-B
Case 10. Patient H. C.

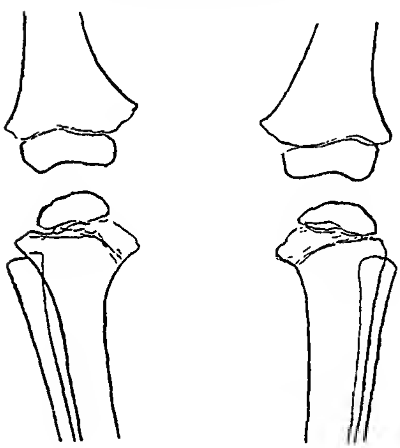


Fig. 23-C
Case 11. Patient A. J.

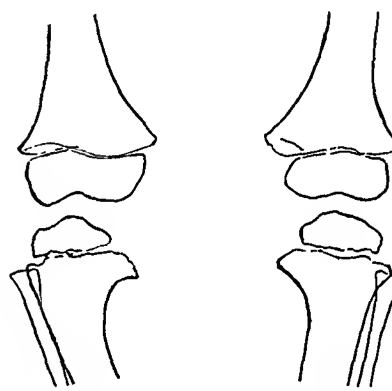


Fig. 23-D
Case 33. Reported by Rall (his Case 2).

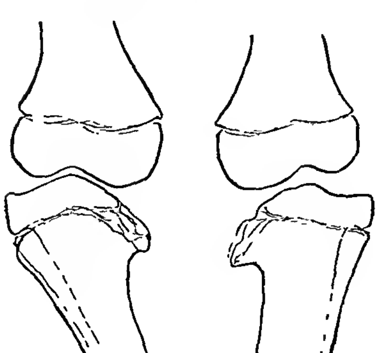


Fig. 23-E
Case 34. Reported by Sloane, Sloane, and Gold (their Case 1).

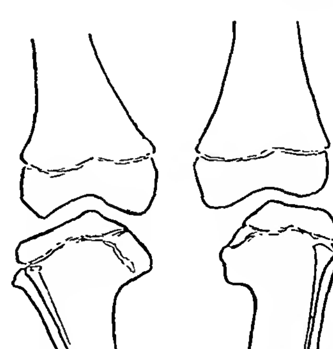
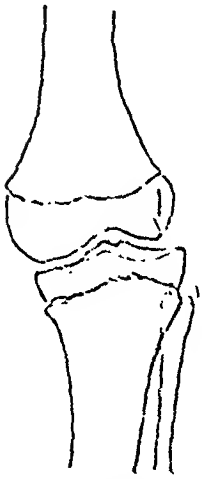


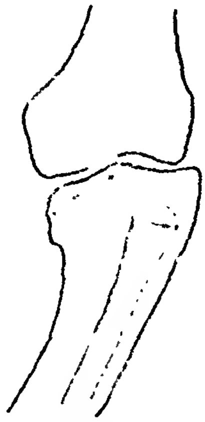
Fig. 23-F
Case 35. Reported by Sloane, Sloane, and Gold (their Case 2).

FIGURE 24

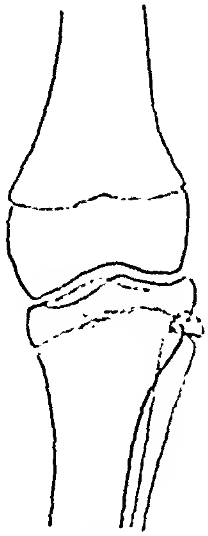
TRACINGS OF OLDER SUBJECTS. THE ADOLESCENT TYPE PREDOMINATES BUT CANNOT BE DISTINGUISHED FROM THE INFANTILE BY ROENTGENOGRAPHIC APPEARANCE



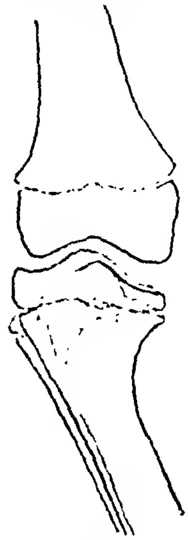
Left
FIG. 24-A
Case 2. Patient G. M.



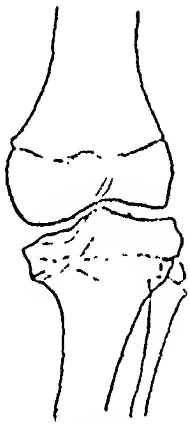
Left
FIG. 24-B
Case 4. Patient F. S.



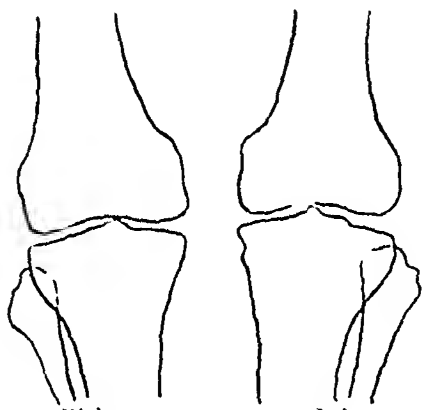
Left
FIG. 24-C
Case 5. Patient B. B.



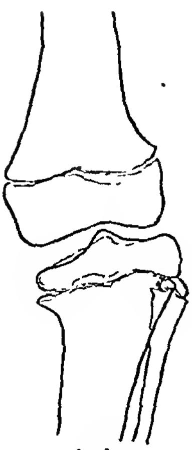
Right
FIG. 24-D
Case 7. Patient M. S.



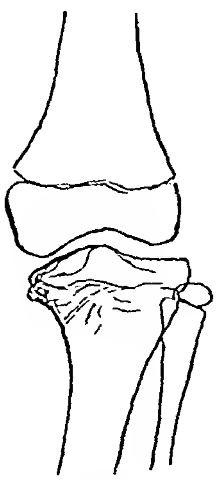
Left
FIG. 24-E
Case 8. Patient H. P.



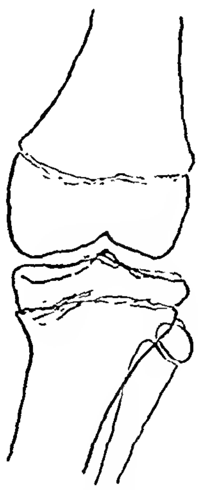
Right Left
FIG. 24-F
Case 12. Patient R. W.



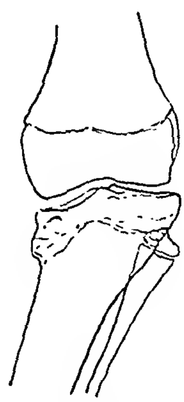
Left
FIG. 24-G
Case 13. Patient M. B.



Left
FIG. 24-H
Case 24. Reported by Lülsdorf (his Case 1).



Left
FIG. 24-I
Case 25. Reported by Lülsdorf (his Case 2).



Left
FIG. 24-J
Case 26. Reported by Lülsdorf (his Case 3).

FIGURE 25

TRACINGS OF MISCELLANEOUS CASES REPORTED ELSEWHERE BUT DIFFERING RADICALLY FROM TIBIA VARA

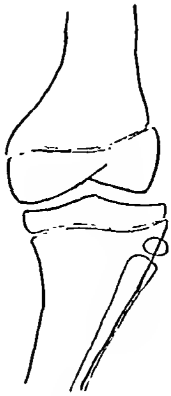


FIG. 25-A
Case 14. Reported by Kirmisson.

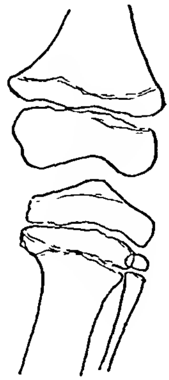


FIG. 25-B
Case 16. Reported by Valentin.

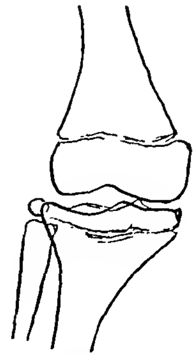


FIG. 25-C
Case 28. Reported by Maselli (his Case 1).

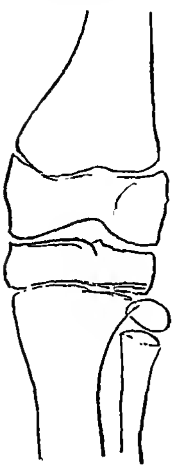


FIG. 25-D
Case 29. Reported by Maselli (his Case 2).

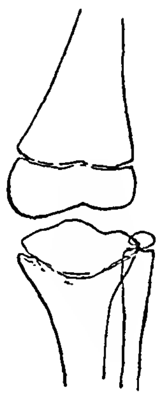


FIG. 25-E
Case 30. Reported by Gickler (his Case 1).

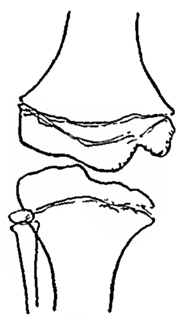


FIG. 25-F
Case 31. Reported by Giekler (his Case 2).

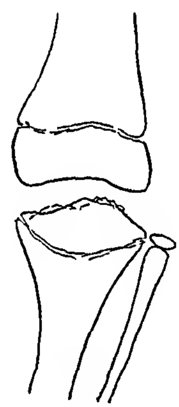


FIG. 25-G
Case 32. Reported by Van Gelderen.

men of causation of this group of diseases have been overthrown one by one.

Rickets used to be blamed for all deformities without other obvious causes. Accurate determinations of the calcium and phosphorous content of the serum have shown them to be normal in various forms of osteochondrosis [11]. Although angulation at the proximal tibial epiphysis can, of course, be the result of rickets, bowing is more frequent than angulation in this disease. In the cases of this series there is nothing in the clinical or roentgenographic findings to suggest rickets.

Hass [22] shows a line drawing which is typical of the adolescent type of osteochondrosis deformans tibiae, but he ascribes the condition to late rickets. This entity may have been a frequent cause of knock-knee and bow-leg in his experience, but we do not see late rickets in the United States. In an admirable review of this disease, Looser published a case with involvement of the medial portion only of the proximal tibial epiphysis. When the late rickets had healed, the deformity would have been indistinguishable from those of the adolescent type of tibia vara. In the active stage, however, one would not have missed in the roentgenogram the clear zone of rarefaction at the epiphyseal line. In 1899, Kirmisson published a case of multiple deformities beginning at the age of thirteen in a girl who had been previously normal. The right knee was angulated into valgus of 150 degrees at the lower epiphysis of the femur. On the left side, a genu varum was the result of an abrupt angulation at the upper tibial epiphysis. These deformities, with a right dorsal scoliosis, were ascribed to late rickets, a term which Kirmisson used synonymously with rickets. The reproductions of the roentgenograms were, of course, poor according to our present standards, but they showed no clear zone of rarefaction at the epiphyseal line which would characterize the lesion as true late rickets. There was no history of dietary deprivation such as usually precedes this disease, but the age of onset and the distribution of lesions were typical. The case was mentioned by several of the other writers and is included in Table II under the grouping "X".

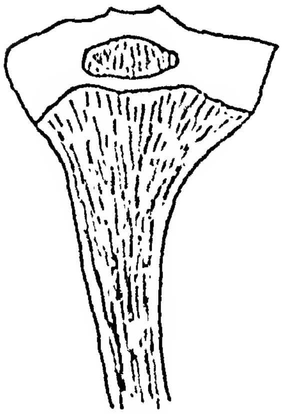


Fig. 26-A

Roentgenogram of the tibia of a three-year-old child. (Redrawn from Böhm [5].)

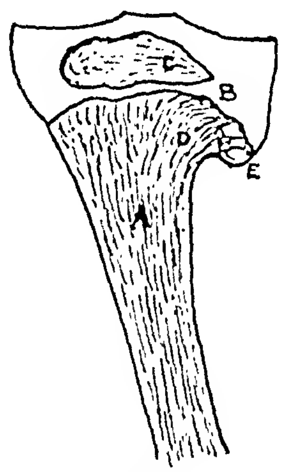


Fig. 26-B

Case 1. Aged three and one-half years. Tracing from the roentgenogram with the cartilage restored. *A:* shaft angulated; *B:* widened epiphyseal line; *C:* wedge-shaped epiphysis; *D:* beaklike metaphysis; *E:* cartilage islands.

With hereditary deforming cartilaginous exostoses one frequently observes a similar angulation at the level of a bony spur. It is easy to understand Mau's confusion of his case with those of Bessel-Hagen and Pels-Leusden. In infantile tibia vara, however, the apparent exostosis is in reality a bulbous prominence. Chondrodysplasia without exostoses [5] is even more confusing. The local condition might well be mistaken clinically for osteochondrosis deformans tibiae. However, the large metaphyseal islands of cartilage, which are characteristic of this disease, would serve to establish the diagnosis in the roentgenogram.

Infection is blamed by Valentin, Lülsdorf, and Maselli. Probably the deformity in Valentin's case (Case 16) was secondary to infection and this case should be excluded from the group. A similar deformity

may follow frank osteomyelitis [3] at the proximal tibial epiphysis. Maselli's cases (Cases 28 and 29) differ from the others in the direction of the angulation. In the first, there is a history of smallpox two years before the appearance of the knock-knee; in the second, typhoid fever preceded the onset of the knock-knee by eighteen months. These infections may have played an etiological rôle, but the evidenee is inconclusive. Lülsdorf considers the deformity to be the sequela of the inflammation of the epiphysis resulting in premature ossification or secondary calcium deposit. There is some evidence to substantiate this suggestion of inflammation. Premature ossification is a constant finding in the adolescent group. Coxa plana has similarly been called by many writers a chronic low-grade osteomyelitis. Pyogenic organisms were isolated after operation by Phemister, Brunschwig, and Day; Kidner; McWhorter; and others.

Fracture into the epiphyseal line will occasionally cause bowing. Growth arrest has followed operations and the use of skeletal traction with encroachment on this cartilage. Following the eradication of a giant-cell tumor of the upper end of the tibia by Putti, a characteristic angulation appeared which looked in the published roentgenogram [43] like the condition under discussion.

Multiplicity of lesions does not rule out tibia vara. The writer has seen simultaneously osteochondroses of the patella, both lower femoral epiphyses, and several secondary spinal centers. A number of multiple osteochondroses have been reported. Naturally such multiplicity is rare when the age of development of each osseous center is different. Nilsonne's Case 2 (Table II, Case 21) and even those cases of Kirmisson and Valentin may have been multiple osteochondral lesions of this type.

Gickler reports two quite different cases as "growth disturbances" and blames a *vitium primae formationis.* He recognizes the similarity to the parallel lesions of the lower femoral epiphysis which give rise to a genu valgum. He compares his cases to those of Lülsdorf. It seems, rather, that his Case 1 (Table II, Case 30, Fig. 25-E) was strikingly like that of Van Gelderen (Case 32, Fig. 25-G) and that his Case 2 (Table II, Case 31, Fig. 25-F) should not be included in this series at all. His Case 1 differs from all of the rest except Cases 28 and 32, in that the epiphyseal line is curved like a dish instead of a dome in the anteroposterior view. This would locate the site of the epiphyseal arrest at the center rather than medially or laterally. In Van Gelderen's case the lesion was slightly to the medial side, giving rise to a varus. Maselli's Case 1 (Table II, Case 28, Fig. 25-C) suggests a similar but less extensive involvement somewhat lateral to the middle but not at the lateral border as in his Case 2 (Table II, Case 29, Fig. 25-D).

Erlacher recognizes the similarity of this lesion to the other osteochondroses and suggests a congenital predisposition as the predominant etiological factor. McCurdy, Langenskiöld, Rall, Rocher and Roudil, and Van Gelderen are satisfied to liken the condition to coxa plana and to presume the same etiology.

In the thirteen cases reported here, and in at least fifteen of those from the literature, there is no evident cause. The epiphyseal lesion must be considered primary in the infantile type. To liken the deformity to coxa plana does not solve the problem of etiology, for the cause of this trophopathy of the capital epiphysis of the femur is undetermined. It does help to identify the cases shown in Figures 21 to 24 inclusive to place them with this group. Speculation as to the probable cause is interesting but not conclusive.

The influence of trauma was early suggested by Legg and has been observed by numerous writers since. There are many cases in which direct trauma has caused a lesion indistinguishable from Osgood-Schlatter disease. Anzilotti even claims that osteochondrosis of the tibial tubercle is not a specific entity. Indirect trauma is certainly the exciting cause in most cases. Indirect trauma may also be the cause of direct cartilage injury or of vascular damage in the proximal tibial epiphysis sufficient to give rise to the changes in the adolescent type of tibia vara. In Cases 2 and 5 there was a definite history of injury three to six months preceding the onset of bowing. In Cases 24 and 25 the possible significance of trauma is as great as that of inflammation.

When a congenital dislocation of the hip is reduced in infancy there may be an immediate change in the capital epiphysis suggestive of coxa plana. On the other hand, the hip may seem entirely normal clinically and roentgenographically until adolescence, when the osteochondral change suddenly occurs. From a roentgenogram taken after puberty it is impossible to tell at what age the deforming process was active. We may be dealing here with a similar lesion. Tibia vara may become apparent as an arrest[10] of the normal development of the leg with exaggeration rather than diminution of the bowing during the first rapid-growth period. Figures 26-A and 26-B show a normal proximal tibial epiphysis at three years in comparison with a tracing of the roentgenogram in Case 1. The hereditary factors mentioned by Nussbaum, Jansen, and Calot fit in with this developmental hypothesis.

A similar deformity may occur at the second rapid-growth period as the result of an epiphyseal disturbance following some minor insult. The occurrence of trauma or infection may be proved, but the *modus operandi* is still uncertain. An x-ray taken later in life, as in Case 4, cannot determine the age at which the process was active.

One reaches the obvious conclusion that the occurrence of osteochondral lesions in general, and those of the proximal tibial epiphysis in particular, is dependent primarily upon the age of the patient and secondarily upon a number of factors. A congenital factor seems to operate when the deformity appears in the first years of life. Later, trauma seems to be the most potent factor with chronic infection a possible second, as suggested by Calvé. The appearance of the lesion clinically and roentgenographically depends a great deal more upon the age at which the noxious influence operates than upon the exact nature of the interference.

The corresponding but less frequent lesion at the lower end of the femur might well be called femur valgum (or varum) or osteochondrosis deformans femoris to differentiate it from coxa plana. Such cases have been recorded by Riedel, Guildal, and Hass [21]. The lesion usually results in knock-knee but occasionally in bow-leg.

PATHOLOGY

In the infantile form the changes consist essentially in faulty growth of the epiphyseal cartilage and delayed ossification of the medial portion of the proximal tibial epiphysis. A beaklike projection of the metaphysis forms secondarily as a buttress under the epiphysis.

In the beaklike prominence, areas of rarefaction are visible roentgenographically. In the microscopic section (Fig. 5) these are seen to be islands of hyaline cartilage such as Perthes described in the bone subjacent to the epiphyseal line of the femoral neck. The cells are irregular in distribution rather than columnar as they should be in a normal epiphysis. The appearance is strikingly like that of a localized chondrodysplasia. The term could better be applied here than achondroplasia, as suggested by Gonzales-Aguilar. Both, however, are already used to designate clinical entities which are distinct from the one under consideration.

The adolescent type looks different in the roentgenogram: It is an arrest of epiphyseal growth, rather than a dysplasia. The difference in pathology is more apparent than real, however. The age of the patient has more to do than the exciting cause with the appearance of the lesion. In support of this fact are the changes occurring in Case 19 (Fig. 22). The first tracing is suggestive of the infantile type and the second, after five years, of the adolescent. Presumptive evidence is even more striking in Case 4 (Fig. 24). The history here is typical of the infantile type. The roentgenogram, taken at twenty-nine years of age, shows nothing to distinguish it from the cases in which angulation appeared at eleven years of age.

SYMPTOMS

The symptoms are independent of the age at onset. Gradually increasing bowing occurs without apparent cause and without the other symptoms of rickets. The deformity is likely to appear bilaterally in the infantile cases, frequently with subsequent spontaneous disappearance of the bow-leg on one side. In the adolescent group the angulation usually occurs only on one side. There is a limp in the unilateral cases and a waddle in the bilateral. Pain from strain may be present in the knee or foot of the affected leg.

There is an abrupt angulation with the apex laterally just below the knee joint, but in fat children this appears to be a gradual curve. When the deformity appears in infancy, a bulbous enlargement of the medial condyle is palpable. Internal rotation of the tibia on the femur is a constant finding. Recurvatum and relative flat-foot are present irrespec-

tive of the age. Shortening of from one to two centimeters is usual. Abnormal mobility of the knee on medial strain with normal stability on lateral strain is a constant finding. Relaxation of the medial supportive structures of the knee persists for some time after correction of the deformity by osteotomy. This specific laxity is inaccurately termed "*Schlottern*" by the German writers. A slight effusion into the joint may result from the strain, but in those cases with marked pain and swelling the deformity must not be classed with the osteochondroses.

General medical examination is negative. There are no findings suggestive of rickets, tuberculosis, or syphylis, and specific tests for the last two are negative.

TREATMENT

As in the other osteochondroses, the deformity of the osseous center is more pronounced than that of the epiphyseal cartilage. Spontaneous healing with restitution of normal contours of the end of the bone may occur as in coxa plana. The likelihood of such an outcome has not been shown to be increased by the use of braces or of other types of support. Symptomatic mechanical relief of the relative flat-foot and knee strain are always indicated. This may be all that is necessary in the mild case. Where actual shortening is present, mechanical equalization of the length of the legs may diminish the limp. If possible, these conservative measures should be continued during a period of observation of several years. When the deformity remains stationary osteotomy should be performed,—in adolescents for cosmetic reasons and in adults when function is greatly disturbed.

The exact time for operation must be determined in each case. If the epiphyseal line is actually damaged, the deformity will become progressively worse until after the epiphysis is closed. In the late cases it is well, therefore, to wait until this time. The infantile type seems to remain stationary after three or four years as though the interference with growth had been temporary. As illustrated by Case 1, there is the possibility of lasting correction following early osteotomy. As typified by Cases 26 and 27, repeated recurrences may supervene. A guarded prognosis is the only safe one.

The curved osteotomy suggested by Langenskiöld is ingenious but not necessary in most cases. It has the theoretical advantage of adding length. Correction of the bow-leg diminishes the shortening. In young children one is likely to obtain additional length from any osteotomy by virtue of the attendant stimulation of bone growth. If properly executed, the simple transverse division also adds length by angulation. If a bone wedge is inserted, a simple leg cast with the knee slightly flexed will suffice. With a peg-leg spica, the bone wedge may be omitted and ambulation allowed without crutches.

The possibility of arrest of the growth of the epiphysis on the opposite side, according to the technique of Phemister, was considered. This

would add to the shortening, however, and really would be less desirable than osteotomy, which would increase the length. Compere, in Case 8, fused not only the proximal tibial and fibular epiphyses on the affected side in combination with osteotomy, but also those on the sound side.

Recurrence must be attributed in part to the progressive nature of the deformity. In Cases 2, 22, and 23 there was an additional factor. The abnormal mobility on medial strain of the knee absorbed about half of the angulation. What appeared to have been overcorrection turned out to be incomplete reduction of the deformity when the cast was removed.

Not appreciating the above facts, several of the writers have blamed the lack of postoperative support for the recurrence of the deformity. After solid bony union has occurred, there is little need for further fixation. Overcorrection must be maintained until this time, however.

SUMMARY

1. Thirteen new cases and fifteen from the literature illustrate the occurrence of an osteochondrosis similar to coxa plana and Madelung's deformity, but located at the medial side of the proximal tibial epiphysis.

2. The resulting abrupt angulation into varus with back-knee and internal rotation of the leg is usually confused with rickets.

3. The roentgenographic and pathological changes are like those of coxa plana and similar to those of chondrodysplasia, but quite different from those of rickets.

4. The changes may appear in the first year or two of life (infantile type) as a developmental exaggeration of the normal, with sloping epiphysis and beaklike recurving metaphysis.

5. A similar deformity may occur just before puberty (adolescent type), secondary probably to local trauma or possibly to infection.

6. The age at which the deformity is observed is more important than the causative factor in determining the roentgenographic appearance.

7. The roentgenographic findings of the infantile type gradually change to those of the adolescent, so that the two can be distinguished later only by the history.

8. Treatment should be directed toward the mechanical relief of strain until the deformity is stationary or until the epiphysis is closed.

9. A simple osteotomy is desirable in the correction of marked deformity. If it is done before the amount of angulation has become stationary, some degree of recurrence may be anticipated.

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A NEW OPERATION FOR HALLUX VALGUS AND HALLUX RIGIDUS

BY G. R. GIRDLESTONE, F.R.C.S., OXFORD, ENGLAND, AND H. J. SPOONER, M.D., REGINA, SASKATCHEWAN, CANADA

The purpose of this paper is to present a new operation for the relief of hallux valgus and hallux rigidus, and to report on the end results of thirty cases. This operation was devised and carried out in the Wingfield-Morris Orthopaedic Hospital. It was designed with the express purpose of avoiding the drawback which besets most, if not all, of the operations at present in vogue,—namely, the tendency to bring about or to increase splaying of the forefoot and metatarsalgia.

Hallux valgus is a twofold deformity,—valgus of the proximal phalanx of the great toe and varus of the first metatarsal. Normally the metatarsal heads are held in place *indirectly* by the muscles *inserted* into their phalangeal caps. (See Figure 1.) The forefoot is splayed, not through stretching of the adductor structures, but because the first metatarsal head escapes from the control exercised by the base of the proximal phalanx into which these muscles are inserted. The phalanx and sesamoids remain held by the adductors, while the first metatarsal head drifts away out of control. (See Figure 2.)

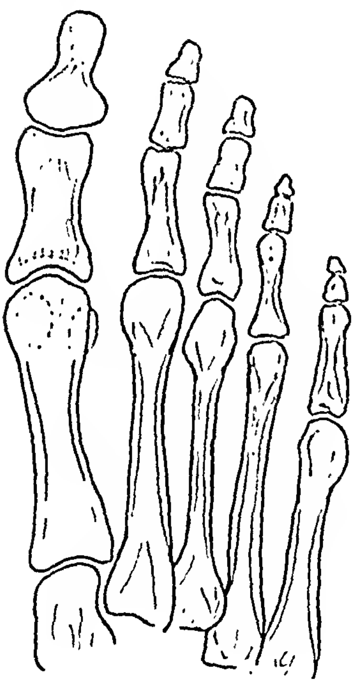

FIG. 1

The normal relationship between the metatarsals, the phalanx, and the sesamoids.

Hallux rigidus is a quite different disability, a disease rather than a deformity.

It is true that hallux valgus and hallux rigidus are sometimes coexistent, and that, therefore, an ideal operation should cure both. The operation which we advocate meets this test.

The most common operations have been:

1. Resection of the head of the metatarsal after the method of Mayo. This operation gives a fair cosmetic result, but, if enough bone is taken to free the joint, it interferes seriously with the important weight-bearing functions of the metatarsal head.

2. Hemiphalangectomy, subtotal, or total phalangectomy, combined with remodeling of the non-weight-bearing surface of the first metatarsal head. This operation can be relied on to produce a painless joint. However, because it removes entirely the insertion of the adductor structures, it has an unfavorable effect on the splaying of the forefoot, which in hallux valgus is the fundamental and the disabling part of the deformity.

In treating hallux rigidus it has been the practice, at the Wingfield-Morris Orthopaedic Hospital, for some eight or nine years previous to 1935, to do a partial phalangectomy, or, if the phalanx is short, a complete phalangectomy, with remodeling of the non-weight-bearing part of the head of the first metatarsal. One of us (G. R. G.) was introduced to this operation by Sir Robert Jones and Mr. T. P. McMurray, and the advisability of removing *at least* one-half of the phalanx was pointed out by the latter. We have found that occasionally we have removed too little of the phalanx, never too much.

Many of the patients with well-developed hallux valgus complained also of metatarsalgia. In each case the patient had a wide, splayed forefoot with prominent metatarsal heads. In such a case a partial or total phalangectomy of course did nothing to relieve the metatarsalgia. On the other hand, in some cases in which the patients had not complained of metatarsalgia previous to operation, metatarsalgia developed after the operation. For these reasons, one of us (G.R.G.) has for a long time felt the need of an operation which would relieve metatarsalgia rather than tend to produce or to aggravate it by removing the point of insertion of the adductor structures.

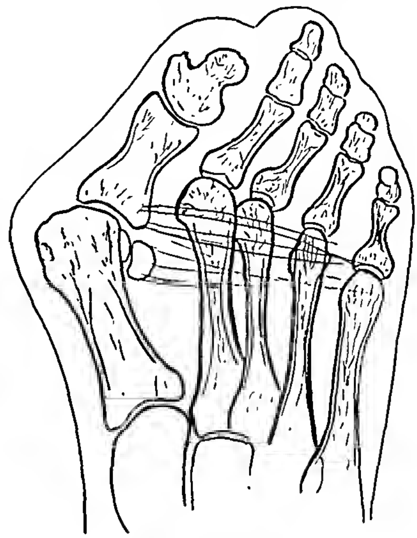

Fig. 2

The typical alteration present in hallux valgus.

If the anatomy of this part of the foot is considered, it is seen that the forefoot can carry the weight of the body comfortably provided that:

1. The metatarsal range is not splayed,—*i.e.*, that the ligaments and muscles holding them together are intact.

2. The normal metatarsophalangeal relationships are present.

The change in the metatarsophalangeal relationships associated with claw-toe or claw-foot is not dealt with in this paper, but we shall consider the metatarsals and the structures which hold them together,—the internal ligament and the adductor transversus hallucis. The intermetatarsal ligament is a narrow band running across and connecting the metatarsal heads. It blends with the plantar ligaments and is attached firmly to the bases of the first phalanges. The adductor transversus hallucis arises from the plantar metatarsophalangeal ligaments of the third, fourth, and fifth toes and from the transverse ligaments of the metatarsus; the adductor obliquus hallucis arises from the bases of the second, third, and fourth metatarsal bones and from the sheath of the tendon of the peroneus longus. These muscles are inserted via the fibular sesamoid and tendon into the fibular side of the base of the first phalanx of the great toe.

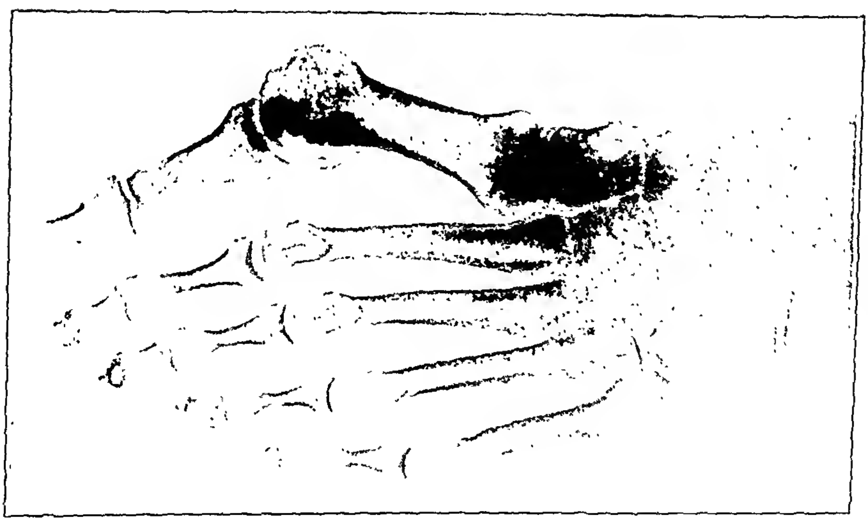

Fig. 3

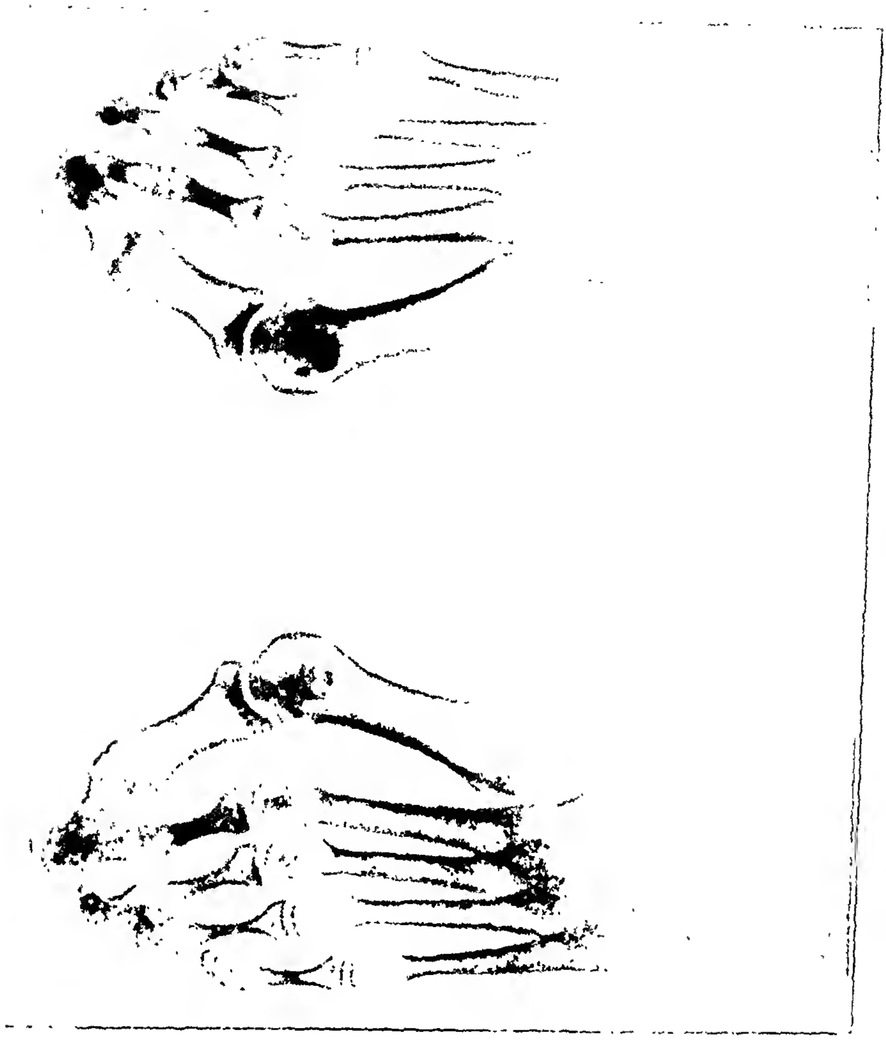

Fig. 4

Roentgenograms showing the loss of the normal relationship between the sesamoids and the first metatarsal, and splaying of the forefoot.

It is interesting to note that the first metatarsal head is kept in its normal position indirectly and by means of its phalangeal cap exactly as are the other metatarsals. Therefore, if the base of the phalanx is removed, the attachments of the adductor structures are permanently lost, and the first metatarsal head drifts away.

Figures 3 and 4, which are typical of the common findings, show that, when the forefoot is splayed, the first metatarsal has lost its normal relation to the sesamoids. The ideal operation would utilize and intensify the action of the adductors rather than abolish the assistance which they were still able to give.

The following operative technique was devised by one of us (G.R.G.) in December 1934.

TECHNIQUE OF OPERATION

A straight incision is made along the tibial side of the foot, extending from just below the interphalangeal joint of the great toe to about one inch above the head of the first metatarsal. The skin is reflected; the

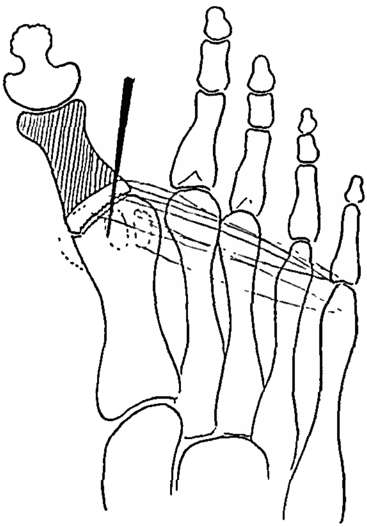

FIG. 5
Brad-awl in place, fixing the phalanx in the corrected position.

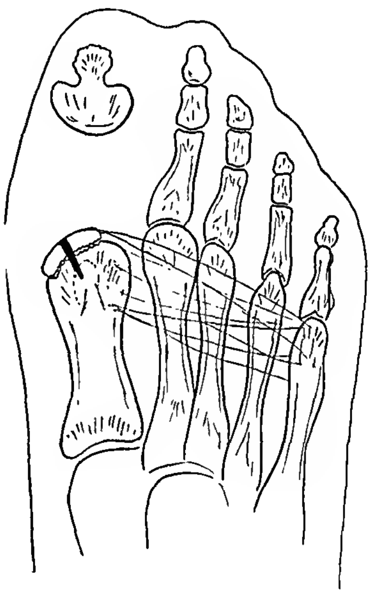

FIG. 6
Operation completed.

hemorrhage is controlled; and, with a second knife, the incision is continued down to but not through the periosteum. If a bursa is present, it is excised. Blunt dissectors are inserted extraperiosteally around the shaft of the proximal phalanx and, as these are separated, the shaft is exposed.

The metatarsophalangeal joint is opened by a transverse incision, leaving a sufficient margin of capsule attached to the tibial side of the first phalanx.

The interphalangeal joint is then opened and the whole distal end and

shaft of the phalanx are freed with a knife or gouge. The phalanx is grasped with a pair of lion forceps and the basal articular surface of the phalanx is denuded of cartilage and freshened.

The exostoses on the head of the first metatarsal are removed with a chisel and nibblers and the head is remodeled, without alteration of its weight-bearing surface. The head is cut away even more, in order to leave a small shelf on the tibial side, so that the phalangeal cap is fitted into the head at this point without a ridge.

A bandage is then tied firmly around the metatarsals, just above the heads, to bind them closely together.

The distal end of the phalanx is again grasped in lion forceps and pulled as far as possible toward the tibial side of the head of the metatarsal, and a brad-awl is inserted through the base of the phalanx into the head of the metatarsal, in order to hold it firmly in position. (See Figure 5.)

The base of the phalanx is then sawed and nibbled through, leaving as thin a cap of bone as possible. The distal portion of the phalanx is removed. The cap of bone is rounded off and smoothed with nibblers and a file. Another brad-awl is introduced through the cap of bone into the head, and a beef-bone pin is driven through the hole. This fixes the cap of bone in place and the first brad-awl can be removed. (See Figure 6.)

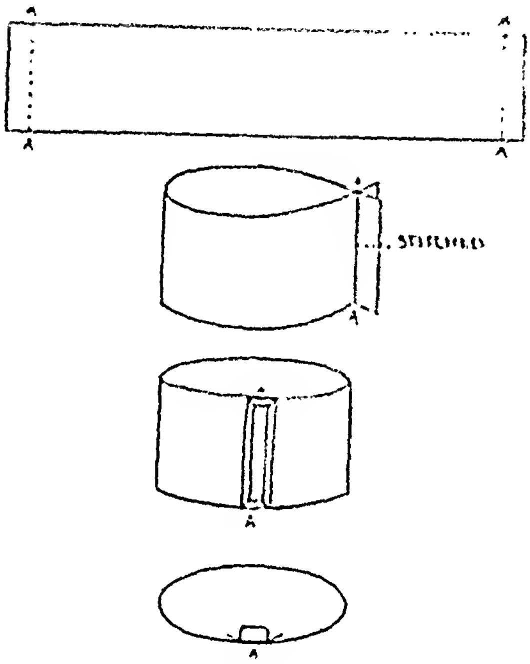

FIG. 7

The construction of a metatarsal strap. (The central pad should be broader and more oval than in the diagram.)

The capsule is then sutured on the tibial side, giving the cap of bone additional support. The wound is closed in two layers with deep and skin sutures. Dressings are applied with the forefoot firmly bandaged to hold the metatarsals together.

The dressings are left undisturbed for ten days, and the patient is not permitted to bear weight. The stitches are then removed, and the arch is held by adhesive strapping with a small felt pad, approximately half an inch by two inches, placed on the plantar surface of the foot just above the second and third metatarsal heads. The patient can begin to walk on the foot in a fortnight. This strapping is kept on for approximately six weeks until roentgenograms show that there is union between the cap of bone and the metatarsal head.

The strapping is then removed and a metatarsal strap is applied for a varying period. (See Figure 7.) These metatarsal straps are made

as follows: The circumference of the foot is measured just above the metatarsal heads, — *e. g.*, eight and one-half inches. A piece of two-inch pink elastic webbing, nine and one-half inches long, is cut and the ends are turned back and sewed together, as indicated in Figure 7. A piece of Sarbo rubber, half an inch by two inches, is cut, and the edges are rounded off, covered with chamois, and sewed to the strapping at the joint. This may then be fitted on the forefoot, just above the metatarsal heads, with the pad in the midline of the plantar surface of the foot.

END RESULTS

The end results of thirty cases in which this operation was performed were compared with those obtained in twenty of the cases in which total or subtotal phalangectomy was done. The latter cases were picked at random and reviewed from the standpoint of metatarsalgia both before and after operation. The patients in this group ranged in age from fourteen to sixty-eight. Three had a definite history of metatarsalgia previous to operation. After operation ten complained of metatarsalgia and had a wide, splayed forefoot, although they obtained some relief from wearing a metatarsal strap continuously.

The thirty patients operated on with the new technique ranged in age from fourteen to sixty-three. Thirteen complained of metatarsalgia previous to operation. Only one of these complained of metatarsalgia following operation. The remainder did not complain of metatarsalgia before or after operation. Of the thirty, twenty had originally some splaying of the forefoot, with or without metatarsalgia, before operation. After operation only four had any marked degree of splaying.

The results of the operation described have proved most satisfactory and the authors are entirely convinced of the value of the method.

THE USE OF BONE CHIPS IN THE TREATMENT OF LOCALIZED OSTEITIS FIBROSA

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From the Department of Orthopaedic Surgery, State University of Iowa, Iowa City

In two other papers[1,2] the problems of localized osteitis fibrosa and giant-cell tumors have been considered by the author from different angles. In regard to treatment, these papers dealt mainly with the evaluation of x-ray therapy and surgical interference. No definite conclusion could be reached concerning x-ray treatment, principally because of insufficient observations. It seemed, however, that the use of bone chips was of great importance in treating certain forms of localized osteitis fibrosa.

Two of the cases (Cases 1 and 5) which were used in the two previous papers are included in this study, with the addition of a few observations which, apart from the question of treatment, are also of considerable interest.

CASE 1. A boy, seventeen years of age, was seen complaining of pain and weakness of the left leg. He had had a severe trauma to the ankle ten years before admission. There had been some draining sinuses, and walking had been considerably impaired for about two years.

On admission, there was a bulbous enlargement of the lower portion of the leg, and the roentgenogram (Fig. 1-A) showed a smoothly outlined cyst of the size of a goose's egg in the lower metaphysis of the tibia.

The cyst was opened, curetted, and partially filled with bone chips removed from the same tibia. (See Figure 1-B.) The wound healed well, except for the upper corner, from which for some time there was a seropurulent discharge, and a few of the chips were expelled.

One and a half years after the operation the patient felt perfectly well. The lower end of the tibia had lost a great deal of its previous enlargement and the wound was healed. Roentgenographic examination (Fig. 1-C) showed good regeneration,—the cavity was filling in by coarse trabeculation and the size of the bone was definitely getting smaller.

In this case of a bone cyst in the lower metaphysis of the tibia, there was good healing after curettage and implantation of bone chips, despite mild postoperative infection with sequestration of a few of the bone chips.

CASE 2. A girl, five years of age, had fallen and had injured the right thigh three weeks before admission. Since that time she had refused to walk.

A roentgenogram (Fig. 2-A) revealed a cyst with smooth, thin, bony walls in the upper end of the right femur. The cyst was placed a little more toward the diaphysis than is usually the case, but without being a true diaphyseal cyst. There was no definite sign of fracture. A window, one inch long and two inches wide, was made in the atrophic cortex, through which the cyst was exposed and opened. The cavity was filled with clear serous fluid, and the wall was covered by a velvetlike fibrous membrane. After a thorough curettage, numerous bone chips, removed from the opposite tibia, were densely packed into the cavity. The limb was then immobilized in a hip spica.

The implanted bone chips took very nicely (Fig. 2-B), and the cavity became solidly filled with bone within the short time of three months. Roentgenograms taken one-half

FIG. 1-A

Case 1. A boy, seventeen years of age, with a bone cyst in the lower end of the tibia. Roentgenogram, April 20, 1933, before operation.

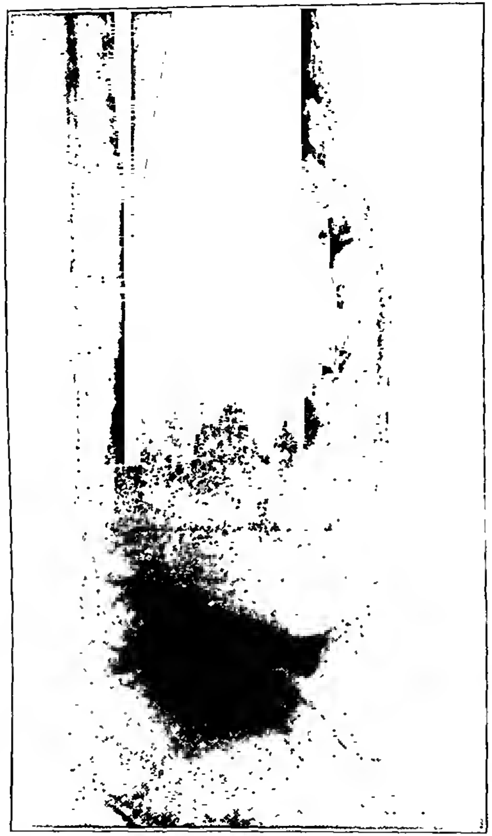


FIG. 1-B

Case 1. After curettage and implantation of bone chips, July 12, 1933.

FIG. 1-C

Case 1. About two years after operation, March 23, 1935, showing good regeneration.

year after the operation showed the defect filled very well with an irregular and dense bony tissue, which revealed signs of structural (functional) transformation.

This case of a simple bone cyst shows the excellent result of surgical treatment with numerous bone chips. It is very unlikely that simple conservative or x-ray treatment or mere curettage would have given such a quick and gratifying result.

CASE 3. A woman, forty-one years of age, was admitted with tenderness of the left foot of one year's duration. There was moderate swelling over the metatarsal heads, which was particularly painful.

The roentgenogram (Fig. 3-A) showed a cystic lesion in the diaphysis of the third metatarsal bone. The distal half was enlarged to about three times its normal size, and the cortex was thinned out and interrupted in a few places. The cystic area was multilocular and was surrounded by some osteosclerosis at the proximal end. The distal epiphysis was reached, but not involved.

The case presented some diagnostic difficulties. Benign enchondroma and localized osteitis fibrosa received the most consideration. The age was unusual for both affections, but the pure diaphyseal localization favored localized osteitis fibrosa despite the unusual localization in a metatarsal bone.

An exploratory operation was performed under tourniquet. The periosteal surface

FIG. 2-A

Case 2. A girl, five years of age, with a cystic lesion in the upper end of the femoral diaphysis. Roentgenogram, August 12, 1935, before operation.

FIG. 2-B

Case 2. Two months after curettage and implantation of bone chips. October 30, 1935.

FIG. 3-A

Case 3. A woman, forty-one years of age, with a multiloculated cystic lesion in the third metatarsal bone. Roentgenogram, July 13, 1935, before operation.

FIG. 3-B

Case 3. Six months after curettage and implantation of bone chips, January 27, 1936.

over the involved area was slightly irregular, but smooth. The periosteum could easily be stripped. The cortex over the dorsal side was thinned and reddish, due to hyperaemia of the underlying bone marrow, and it covered a system of small cysts which were filled with serous fluid and walled out by a velvetlike fibrous membrane. The cystic area was curetted until only the thin cortex preserved the continuity of the bone. The defect was densely filled with loose bone chips which had been removed from the lower end of the left tibia. The limb was then immobilized in a short cast.

The postoperative and pathological diagnoses were definitely localized osteitis fibrosa cystica; there were no signs of cartilaginous tumor formation.

All the bone chips took very nicely and the defect soon became filled by well-organized bony tissue. (See Figure 3-B.) The enlargement of the metatarsal bone has decreased, and a full restoration of contour and function can safely be expected.

In this unusual case of localized osteitis in a metatarsal bone, thorough curettage, followed by a dense filling of bone chips, secured an excellent result.

CASE 4. A boy, sixteen years of age, was seen, complaining of pain in the right ankle, which had followed participation in a football game one year previously. He could recall no special trauma. There was tenderness just anterior to the ankle joint toward the outer malleolus. Motion was painful only on forced dorsiflexion.

Roentgenograms revealed a cystic lesion of the size of a small walnut in the lateral portion of the body of the astragalus. The walls were smooth without any surrounding bone reaction.

An operation was performed by Dr. Arthur Steindler. Through the thinned-out cortical bone of the neck, a large cyst was opened, which contained a straw-colored fluid. The wall consisted in part of dense fibrous tissue, and in part of more reddish-gray granu-

lar material. After curettage, bone chips, removed from the tibia on the same side, were packed into the cavity and the leg was immobilized in a long cast.

The pathological examination revealed a considerable number of giant cells, as well as simple fibrous tissue. The diagnosis of a cystic giant-cell tumor was made.

The patient made a good recovery.

CASE 5. A girl, eighteen years of age, had sustained a lateral dislocation of the left knee three years before admission. She had had pain in the knee before the dislocation and roentgenograms had revealed "weakness" of bones. The dislocation had been reduced and the leg had been immobilized. Since that time the patient had had limitation of motion.

FIG. 4-A

Case 5. A girl, eighteen years of age, with a giant-cell tumor in the lower end of the femur. Roentgenogram, June 27, 1934, before operation.

FIG. 4-B

Case 5. After curettage and implantation of bone chips, December 27, 1934.

FIG. 4-C

Case 5. About one year after operation, July 29, 1935.

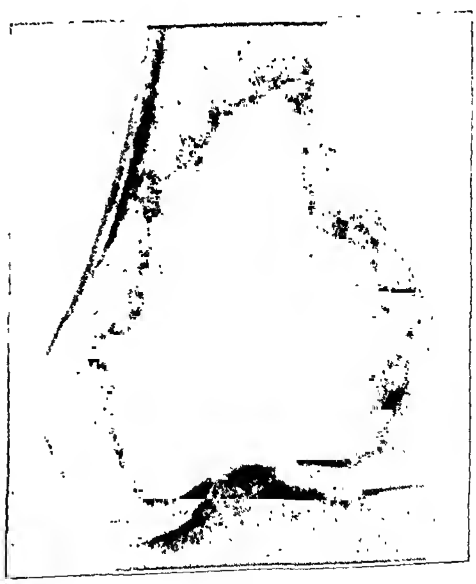


FIG. 4-D

Case 5. One and one-half years after operation, November 29, 1935.

Examination showed considerable valgus deformity of the knee. There was no swelling except for the lateral condyle of the femur, which was enlarged and could easily be palpated anteriorly. Motion was present from 180 degrees to 145 degrees.

Roentgenograms (Fig. 4-A) showed a large cystic lesion in the lateral condyle of the left femur, expanding the cortex on the lateral side without breaking through it. The walls of the cyst were not smooth.

Under tourniquet, a very careful curettage was done until healthy bony tissue was revealed. Many small bone chips were removed from the left tibia, and the huge defect was filled three-fourths full. The hip was immobilized in a spica.

The pathological report was: "Giant-cell tumor."

All the bone chips took very well (Fig. 4-B) and most of them became centers of quite active osteogenesis. The routine roentgenographic check-up (Figs. 4-C and 4-D) showed a gradually increasing homogeneization of the bony structure. There were no signs of tumor recurrence.

In this typical case of giant-cell tumor in the lateral condyle of the femur, treated by thorough curettage and bone chips, there was very good healing without signs of recurrence sixteen months following operation.

Case 6. A woman, thirty-nine years of age, was admitted, complaining of pain in the right knee of six years' duration. She had been unable to walk on the leg. Shortly before admission, the leg had drawn up. There was a very marked enlargement of the region of the right knee (right knee, 45.5 centimeters; left knee, 39.0 centimeters) with increased local heat. Some tenderness was noted over the femoral condyles. Motion was present from 150 degrees to 90 degrees, with grating and pain.

Roentgenograms (Fig. 5-A) revealed a multilocular cystic tumor in the lower end of the femur, involving both condyles and extending up to the border of the middle and lower thirds, where signs of an old united transverse fracture were present. The clinical diagnosis was giant-cell tumor; the roentgenologist favored chondrosarcoma. To establish the diagnosis, an exploratory operation was indicated.

Under tourniquet, the lower end of the femur was exposed and a typical giant-cell tumor was found. A thorough curettage of the lower epiphysis of the femur was done. Both condyles were occupied by solid tumor tissue which extended down to the joint cartilage. A large number of bone chips were removed from both tibiae and were implanted into the huge cystic cavity which, however, could be filled only partially.

The postoperative period has been too short to warrant adequate judgment as to the results obtained from the operation. It seems that there is improvement, but the question of local recurrence remains open.

In this case of a very extensive benign giant-cell tumor, involving both condyles of the femur, the outcome is questionable. Such advanced cases of giant-cell tumor represent a very difficult problem for surgery. It is doubtful whether the procedure carried out in this case was adequate, despite the large number of implanted bone chips.

This type of operation was performed mainly because the patient insisted upon the preservation of the knee joint. It seems, however, that a radical resection of the lower end of the femur, followed by a plastic bone-graft operation, is a much wiser procedure in such cases. There are essentially two operative methods to be considered. The first, used by Albee, bridges the defect after resection of the lower end of the femur by several bone grafts taken from the tibia on the same side. One strong graft is firmly inserted into the freshened upper joint surface of the tibia. At least three other sliver grafts are placed around the main graft, so as

FIG. 5-A

Case 6. A woman, thirty-nine years of age, with a giant-cell tumor in the lower end of the femur. Anteroposterior roentgenogram, September 11, 1935, before operation.

FIG. 5-B

Case 6. Lateral roentgenogram, before operation.

FIG. 5-C

Case 6. Anteroposterior roentgenogram taken through plaster-of-Paris cast after radical curettage and implantation of bone chips, September 24, 1935.

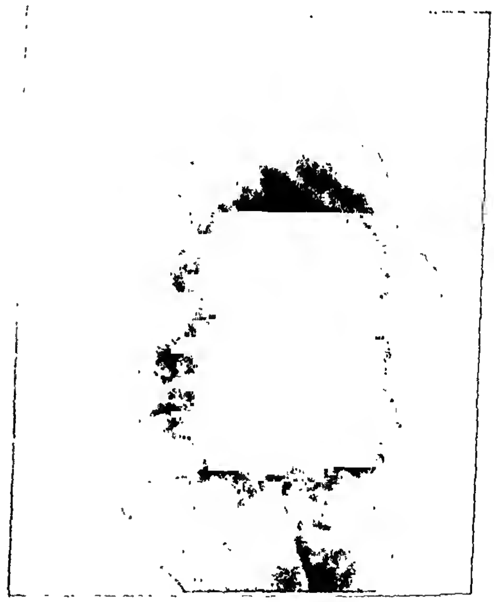


FIG. 5-D

Case 6. Anteroposterior roentgenogram, six months after operation, March 11, 1936.

to form a pyramidal structure. This is further reenforced at the site of the knee joint by the patella, which has been split in two at the beginning of the operation. This is an excellent method, as demonstrated by some of Dr. Albee's cases.

The other method, described by Juvara, uses the front half of the tibia, which is turned to 180 degrees, so as to bring its distal end in contact with the distal end of the femur. Its proximal portion, the head of the tibia, remains in contact with the corresponding part of the posterior half.

In both methods, the knee joint has to be sacrificed. However, the extremity can be preserved in its normal length, and for this reason the method is preferable to amputation. The only inconvenience is the protracted period of immobilization. As a rule, consolidation, sufficient to permit free weight-bearing, takes at least eighteen months.

Case 7. A man, twenty-five years of age, had complained of pain in the left hip for four months. The affection had started suddenly with severe pain over the greater trochanter; the pain had gradually increased and the leg had grown weaker. The patient appeared in excellent general health. Muscle spasm around the left hip and exquisite tenderness on percussion over the greater trochanter and heel were present. Marked atrophy of the left lower extremity was noted.

Roentgenographic examination (Fig. 6-A) showed a purely osteoclastic lesion in the upper end of the femur without sharp outlines and without any form of demarcation.

The roentgenographic appearance was unusual, but it seemed to indicate the presence of a giant-cell tumor. The age of the patient and his general good health. as well as the epiphyseal involvement, favored this diagnosis. To arrive at a certainty, an exploratory operation was indicated.

At operation, the joint capsule was found to be thickened by oedema. The joint cartilage of the head of the femur appeared thin and bluish and could easily be pressed down because of lack of supporting bony tissue. The neck and a large part of the head were occupied by a large cyst, surrounded only by a paper-thin shell of bone. The latter was perforated in several places, but there was no invasion of the surrounding soft tissues by tumor. The cavity extended into the head of the femur as far as the joint cartilage, and further down into the trochanteric region and into the diaphysis. The walls of the cyst were formed by a thin layer of granular tumor tissue which was curetted out. The amount of solid tumor tissue was slight, the lesion being almost purely cystic. Frozen sections confirmed the diagnosis of giant-cell tumor. Therefore, a great many bone chips were removed from the diaphysis and upper metaphysis of the left tibia. Further bony material was obtained from the wing of the ilium. All the chips were implanted into the huge bone defect, filling it quite adequately. (See Figure 6-B.)

The patient made an uneventful postoperative recovery and was discharged. He returned after two months in a markedly run-down condition. He had felt very poorly at home and had had pain in the hip region, sometimes of a sharp, shooting character. The hip region was swollen, showed fluctuation, and was tender. The patient ran a subfebrile temperature. The lungs were clear on clinical and roentgenographic examination.

Roentgenographic examination (Fig. 6-C) revealed definite progress of the osteoclastic lesion, which now had fully destroyed the greater trochanter and the head of the femur and had also extended further down into the diaphysis. Because of the histological diagnosis, the lesion was still considered as a giant-cell tumor of very pronounced activity. It was thought best to resect the upper end of the femur and to replace it by the upper half of the fibula.

At operation, a large amount of brown bloody fluid, containing a few flakes of necrotic tissue or clotted fibrin, escaped. The upper third of the femur was practically gone; there remained only a few eroded portions of bony tissue, representing in part the atrophic lower cortex of the femoral neck, and in greater part the transplanted bone chips which formed a rather dense mass of bone. The large cavity which contained the

bloody fluid was walled off by a very irregular tumor tissue of brownish-red stain with quite extensive necrosis. All the surrounding soft tissues were invaded, and there was extension into the subcutaneous fat tissue. In view of these facts, there could not be any doubt that a highly malignant tumor had destroyed the upper third of the femur

Fig. 6-A

Case 7. A man, twenty-five years of age, with a giant-cell sarcoma of the upper end of the femur. Roentgenogram, July 10, 1935, before operation.

Fig. 6-B

Case 7. After curettage and implantation of bone chips, July 20, 1935.

Fig. 6-C

Case 7. Two months after operation, September 12, 1935. Note the rapid progress of bone destruction.

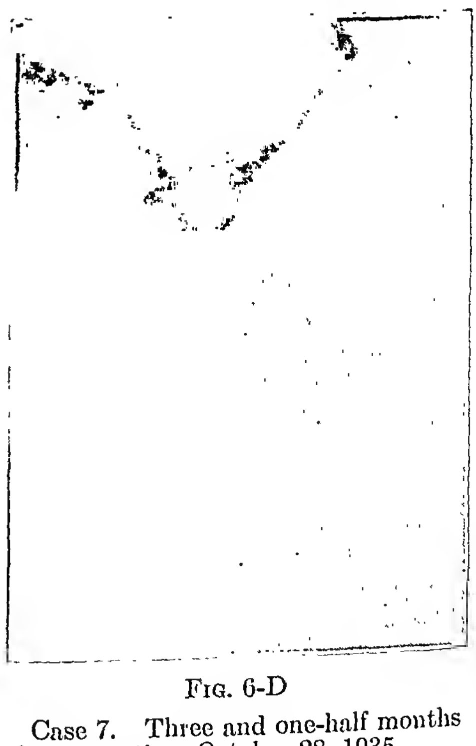


Fig. 6-D

Case 7. Three and one-half months after operation, October 28, 1935.

and was in full and irresistible expansion toward the soft tissues. The tumor was rapidly growing, but also rapidly disintegrating, thus leading to the huge cystic cavity. At the operating table the diagnosis had to be changed from giant-cell tumor to giant-cell sarcoma.

The patient's condition improved slightly after the drainage of the cavity. He received x-ray treatment and was discharged. Metastases to the lungs developed, and the patient died a short time afterward.

In this case (giant-cell sarcoma of the femur), the implanted bone chips resisted fairly well the rapid tumor growth with its osteoclastic activity; they remained balled together in the middle of the huge cavity, whereas the bony tissue of the femur yielded readily. The case appeared to be unusual from the roentgenographic view-point. Although at the time of the first operation the pure osteolytic lesion, with very little solid tumor tissue and a clinical history of relatively short duration, did not seem to be a simple and benign form of giant-cell tumor of bone, the histological picture of the tissue removed at that time appeared to be quite typical of giant-cell tumor. A large number of slides were examined and rechecked later. After the second operation, the histological picture was quite different. There was marked anaplasia of tumor cells with mitotic figures and very irregular giant cells, which looked like a syncytium rather than individual cells. The tumor showed definite affinity to bony tissue. When this tissue was destroyed, the tumor became necrotic and liquefied.

From the difference in the histological picture, one would be inclined to believe that a primarily benign giant-cell tumor had been stirred up by the operation and had undergone malignant changes. The author feels, however, that, despite the difference in the histological picture, this lesion started as a malignant tumor, and he does not think that the degree of malignancy was aggravated by the surgical intervention. However, one has to admit that the latter certainly did not improve the condition. The question arises: What should have been done instead? The lesion was so extensive, even at the time of the first operation, that it seems rather doubtful whether the enucleation in the hip joint would have saved the life of the patient. The only possibility appears to be the interilio-abdominal amputation. This operation was considered when the femur was explored for the second time, but was not carried out because of the patient's poor general condition.

SUMMARY

The use of bone chips is an excellent method of treating localized cystic osteitis fibrosa. It certainly is superior to simple scraping and the use of caustic substances. The cavity can be filled much easier with chips than with solid cortical bone grafts, and it seems also that the power of osteogenesis is greater with the use of chips. Giant-cell tumors are not so susceptible to this form of treatment, especially if they are in the more advanced stage and if too great a defect results after the curettage

of the tumor tissue. Nevertheless, the author obtained a very good result in one case in which the entire lateral condyle was involved.

Care should be taken to fill the defect with the chips as completely as possible. If necessary, both tibiae may be used as donors. In too advanced cases or in recurrent cases of giant-cell tumor, resection with heavy, bridging, tibial grafts is preferable to the less radical procedures, such as curettage and the use of bone chips, and to the more radical ones, such as amputation and exarticulation.

1. Freund, Ernst, and Meffert, C. B.: On the Different Forms of Non-Generalized Fibrous Osteodystrophy. Surg. Gynec. Obstet., LXII, 541, 1936.
2. Freund, Ernst: Giant-Cell Tumors. To be published.

HISTORY OF FRACTURE TREATMENT UP TO THE SIXTEENTH CENTURY *

BY WILLIAM ARTHUR CLARK, M.D., F.A.C.S., PASADENA, CALIFORNIA

Through all the changes in medical and surgical knowledge and in technique in the history of medicine, there are some subjects, such as obstetrics and fractures, in which, because of their nature, there has been very little change. The broken leg and the blessed event are traditionally linked with the doctor in caricature and story. It is, therefore, easier to trace the history of fracture treatment back through many centuries than it is to find what was known or done a hundred years ago about some of the "modern" diseases.

Because the mechanical factors in fractures were the same in the first century as they are in the twentieth century, the methods of treatment in ancient times are found to be similar, not only in principle but in practice, to those of our own day. One is astonished to find in medieval text-books descriptions and illustrations of instruments which, if nickel-plated, might be mistaken for equipment in our modern hospitals. It might be supposed that extension methods by windlasses, levers, ratchets, and pulleys may have had their inception in the torture chambers of the Spanish Inquisition, but, as a matter of fact, they date back to Hippocrates. As to splints, the simple and primitive expedient of holding together the parts of a broken staff by binding them to a sound staff would naturally occur to any people of intelligence and its application to a broken bone would not be very hard to imagine.

Prehistoric man must have had his troubles with broken bones. According to Sudhoff, the bones of Neolithic man show traces of attempts at corrections of deformities. Apparently enough specimens of fractured bones from that age have been found to justify statistical statements. Karl Jaeger found 53.8 per cent. of good unions as against 46.2 per cent. of bad unions in prehistoric fractures, a noteworthy achievement on the part of the Neolithic man.

EGYPTIAN METHODS

Recorded descriptions of the methods of Egyptian physicians are very scanty. Our knowledge of those days comes more from the finding of remains of their handiwork than from their writings.

In the Edwin Smith Surgical Papyrus are found sketchy references to fractures of the clavicle, the humerus, and the cervical spine. "If thou examinest a man having a break in his collar-bone, . . . thou shouldst place him prostrate on his back, with something folded between his two shoulder-blades; thou shouldst spread out with his two shoulders

* Read at the Annual Meeting of the American Orthopaedic Association, Milwaukee, Wisconsin, May 19, 1936.

in order to stretch apart his collar-bone until that break falls into its place. Thou shouldst make for him two splints of linen, (and) thou shouldst apply one of them both on the inside of his upper arm and the other on the under side of his upper arm. Thou shouldst bind it with *ymrw*,* (and)treat it afterward [with] honey every day, until he recovers." Treatment for the humerus is described, but the text is practically the same as for fracture of the clavicle.

An impacted fracture of a cervical vertebra, caused by a fall in which the patient landed on his head, is mentioned, but there is no reference to treatment. It is stated, however, that the accident was fatal.

Archeological excavations have yielded a great number of specimens of fractures, some healed and others in splints not yet united. Fractures of the forearm bones are most numerous, supposedly because the arm was used in defense against blows with the "naboot". In excavating in the Nubian desert, a graveyard was found, which contained remains of bodies with fractured limbs that had been set with bark splints. One specimen was a femur, which was held in position by a splint and bandage and was tied with true reef-knots. The wrappings of palm-fiber cloth "were set just as a good surgeon would set them in these days so as to use the full strength of the fabric".[7] From the Nubian excavations also came several specimens of forearm fractures which are now in the museum of the Royal College of Surgeons in London. One of these, examined by the author, is a model of neat splinting with wood from the stems of palm leaves, the padding being of coarsely woven cloth such as we today would call homespun. On turning back the posterior splint, the fracture of both bones is visible, the soft tissues having almost vanished. There is good approximation, but no union. Mr. Cave of the Museum says: "The splints are applied without any attempts at control of the fragments. Similar splints were employed in the repair of royal (and other) mummies damaged by the tomb-plunderers of antiquity; and since, in Egyptian eyes, the mummy was ceremonially alive, this office exactly corresponded to the treatment of a living patient. Splints of a similar nature are still employed in the Sudan and Abyssinia, and in Borneo and elsewhere in the Malay Archipelago."

HIPPOCRATES (460–377 B.C.)

In the voluminous writings of this Greek scholar, fractures and their treatment are given generous space. Reflecting the high plane of civilization and culture of his time, the chapters devoted to this subject would be a credit to a modern system of surgery. He was explicit in the details of his descriptions of methods. For example, let us quote his directions for treatment of a fracture of the humerus: ". . . having got a piece of wood a cubit or somewhat less in length, like the handles of spades, suspend it by means of a chain fastened to its extremities at both ends; and having seated the man on some high object, the arm is to be brought over, so that

* A metal which cannot be identified.

the armpit may rest on the piece of wood, and the man can scarcely touch the seat, being almost suspended; then having brought another seat, and placed one or more leather pillows under the arm, so as to keep it a moderate height while it is bent at a right angle, the best plan is to put round the arm a broad and soft skin, or broad shawl, and to hang some great weight to it, so as to produce moderate extension; or otherwise, while the arm is in the position I have described, a strong man is to take hold of it at the elbow and pull it downward. But the physician, standing erect, must perform the proper manipulation, having the one foot on some pretty high object, and adjusting the bone with the palms of his hands; and it will readily be adjusted, for the extension is good if properly applied."

He describes mechanical extension for fractures of the thigh or leg: ". . . having fixed in the ground either the nave of a wheel, or any such object, something soft is to be bound round the foot, and then some broad thongs of ox-skin being brought round it, the heads of the thongs are to be fastened to a pestle or any other piece of wood, the end of which is to be inserted into the nave, and it, the pestle, is to be pulled away, while other persons make counterextension by grasping the shoulders and the ham." For counterextension: ". . . fasten deeply in the ground a round, smooth piece of wood, and place the upper extremity of the piece of wood at the perineum, so that it may prevent the body from yielding. . . ." He used a fracture table called the Scamnum which he describes as follows: "But the best thing is, for any physician who practices in a large city, to have prepared a proper wooden machine, with all the mechanical powers . . . either for making extension, or acting as a lever." He recognized the difficulties involved in fracture of the femur and the possibilities of deformity: ". . . for it is a great disgrace and an injury to exhibit a shortened thigh. For the arm, when shortened, might be concealed, and the mistake would not be great; but a shortened thigh-bone would exhibit the man maimed."

In compound fractures he advised against the then common practice of binding the limb on either side and leaving the wound out, because the wound then becomes discolored and gets into a throbbing and inflamed condition. He advised applying to the wound "a cerate mixed with pitch", over which is bound "a thin folded compress"; then "the parts around are to be anointed with white cerate". Splints should *not* be put on, but the bandages should be sufficient to give some fixation, and should be adjusted so that the pus would discharge freely. In summer the bandages were frequently dampened with wine and in winter with greasy wool, moistened with oil and wine.

Permanent fixed extension was obtained in leg fractures by the ingenious use of the springing force of heavy elastic twigs from the cornel tree. Thickly padded rings were put around the leg,—one just below the knee, the other at the ankle. Four of these wood twigs or rods were then placed on the four sides of the leg. They were cut a little longer than the distance between the padded rings and forced in between the

rings by bending. The ends of the rods then impinged against the rings and exerted extension by *their tendency to spring into a straight line.*

Bone skids, such as we use in open reduction, were employed by Hippocrates for reducing protruding bones in compound fractures. He had several different sizes to fit various bones and used them as levers in conjunction with extension. This procedure had to be done before the third or fourth day. "For if the limb is disturbed on these days, and yet the fractured bones not reduced, inflammation will be excited, and this no less if they are reduced; for convulsions are more apt to occur if reduction take place, than if the attempt should fail."

Compound fractures of the femur and humerus were regarded as often fatal, whether or not they were reduced. The dangers which today take the form of malpractice suits are suggested when Hippocrates says: "But one should try to escape from such cases, provided one can do so honorably, for the hopes of recovery are small, and the dangers many; and if the physician do not reduce the fractured bones he will be looked upon as unskillful, while by reducing them he will bring the patient nearer to death than to recovery." He advised treating fractures of the jaw by binding the teeth together with gold or linen thread. He described a succussion method for reducing fractures of the spine. The patient was bound to a ladder, which was then raised perpendicularly with ropes and pulleys and let down suddenly, so that the jolting might reduce the deformity. However, Hippocrates did not practise this method himself. He described the appearance of a heel after the patient had fallen from a height and had landed on the feet, but he probably did not recognize a fracture of the os calcis.

ROME

The dawn of the Christian Era did not bring with it any appreciable activity in development of the medical arts. Rome borrowed her physicians from Greece. Pliny said: "For it is a well-known fact that those physicians who, without being able to speak Greek, attempted to build up a practice in Rome, failed to gain the confidence of their patients, even of those who were not at all familiar with that language." [7] Medical and surgical literature from the Roman Empire is sadly lacking. In the Byzantine period, about the tenth century, the methods of Hippocrates, with modifications and refinements, are seen in the work of Nicetas whose writings are accompanied by drawings, showing methods of permanent extension and reduction by windlasses and pulleys.[4]

ARABIAN SCHOOL

From the ninth to the twelfth centuries a bright spot appears in the form of writings by Rhazes (850–932), Avicenna (980–1037), Albucasis (1013–1106), Avenzoar (1113–1162), and others in Arabia. Avicenna and Albucasis are recorded as being in favor of suturing the flesh wound in a compound fracture. Avicenna practised open reduction. For malunion he advised that the flesh be cut and the callus removed by rubbing

it away, then the bone could be restored to a good position. Causes of non-union were advanced by Avicenna as follows: " . . . multiple embrocations with warm water; and frequent changing and haste and moving the organ; when there is little viscous blood or too great stricture, which prevents the limb from being nourished; or the presence of pieces of bone." [13]

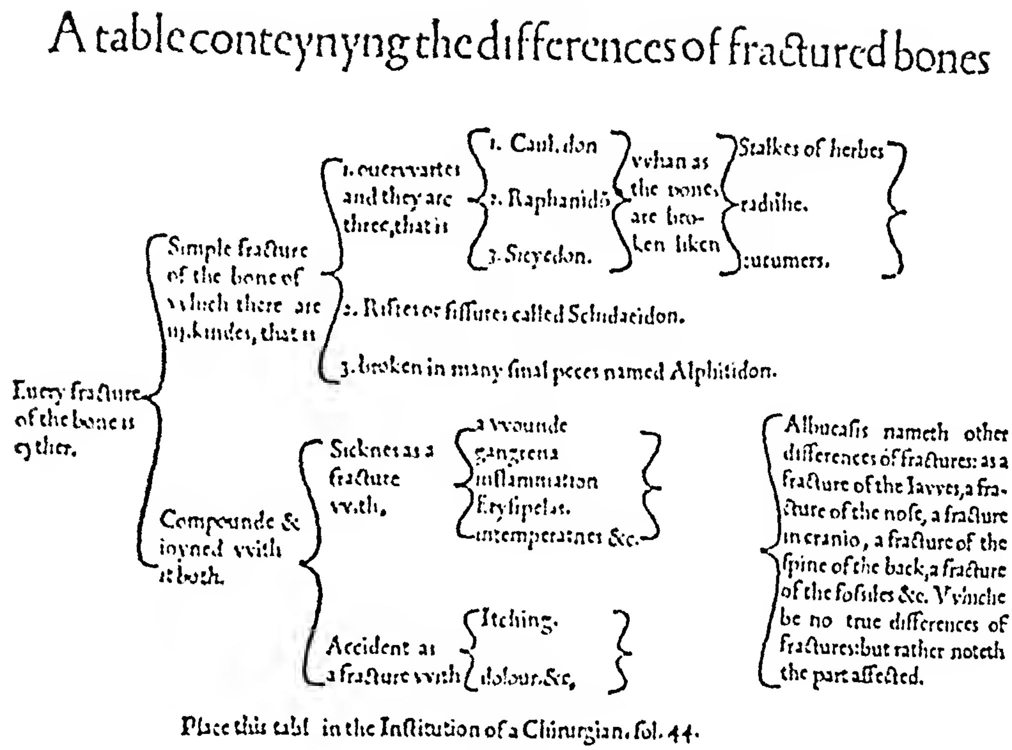
Albucasis used coaptation splints and is given credit for this method by Guy de Chauliac. He held that the bone of the spine could be fractured, but that seems to have been contrary to the general opinion that spinal deformities came only from attrition. He stated that if a patient lost control of the bladder and bowels, following a back injury, the condition was mortal and that it was useless to try to cure it.

GUY DE CHAULIAC (1300–1370)

This French surgeon (also called Guido de Cauliaco) was an authority in his time. He is much quoted by writers for three centuries following his death, and is sometimes referred to as the greatest of medieval surgeons. An old English translation [12] of his "The Questyonary of Surgeans" is written in the form of questions and answers. In reply to the question—"Whether the scyence of nathomye be necessarye and nedefull to the cyrurgen or not?"—he replied: "The same manner that the blinde man worketh in hewynge of a log, so doth a cyrurgen that knoweth not the nathomye."

He emphasized the use of ointments and salves in the treatment of fractures; two pages in this edition are filled with formulae for various mixtures to be applied to the limb. In fact, he is considered by some historians [11] to have been reactionary in this respect and to have delayed progress in surgery by endorsing the doctrine of interference and meddling instead of trusting in the power of nature to heal wounds. Perhaps it was this influence which inspired Paré to say (200 years later) "I dress it, but God cures it."

In a modern translation [13] of Guy de Chauliac's book on fractures, methods of reduction and retention are given in detail. For compound fractures he advised the extraction of "foreign substances such as arrows or pieces of bone", then "the separated parts of the bone should be brought together and the flesh wound deeply sutured and closed firmly". The limb was then bandaged "in such a way that the wound can be attended to . . . without undoing all the bandages and supports". Even then, as today, there was a difference of opinion regarding complete closure of wounds in compound fractures. Guy de Chauliac said: "And how will the bone be repaired unless by the intervening flesh? . . . I believe that nothing nourishes with true nutrition which does not come from the stomach to the liver and to the veins scattered throughout the flesh, hence to the bones. . . ." He described coaptation splints made of willow, sword-handle wood, horn, iron, or leather, but said that they should neither touch nor injure the joint. They should surround the limb about one finger's breadth apart and then be covered with cloth and moistened


A table conteynyng the differences of fractured bones

Every fracture of the bone is eyther.

Simple fracture of the bone of which there are iij. kindes, that is

1. ouerwartes and they are three, that is

1. Caulidon
2. Raphanidō
3. Sicyedon.

when as the bones are broken liken

Stalkes of herbes
radishe.
cucumers.

2. Rifles or fissures called Schidacidon.

3. broken in many smal peces named Alphitidon.

Compounde & ioyned with it both.

Sicknes as a fracture with,

a wounde
gangrena
inflammation
Erysipelas.
intemperatnes &c.

Accident as a fracture with

Itching.
dolour. &c.

Albucasis nameth other differences of fractures: as a fracture of the Iawes, a fracture of the nose, a fracture in cranio, a fracture of the spine of the back, a fracture of the fosiles &c. Whiche be no true differences of fractures: but rather noteth the part affected.

Place this tabl in the Institution of a Chirurgian. fol. 44.

FIG. 1

A sixteenth-century classification of fractures from "Certaine workes of Chirurgie", by Thomas Gale, 1563. (From the rare-book collection, The Huntington Library, San Marino, California.)

with egg white. This egg-white method is mentioned in many surgical writings of medieval times. It is probable that it served to stiffen the bandages as does plaster-of-Paris. A method of tightening and holding the splints was to "have some cannulae tied with a cord, . . . and let the splints be bound with the cord so that by twisting the cannulae they may be sufficiently tightened; then a little rod is passed through the cannulae in order that they do not lose their revolution and tightness". He advised "a cradle or suspensory in which the limb will be firmly and evenly placed" and "a mattress bed on which the patient sleeps, . . . perforated so that he may go to stool" and a "cord hanging over the bed, or some other thing for him to catch and help himself when he wishes to go to stool or straighten or turn himself". Splints were only to "sustain" during the first seven days until swelling subsided, after which they were to be placed in such a way as to actually restrain the bones. A diet of rice, wheat cooked in water, boiled feet, viscera, and heads of animals, and strong astringent wine was prescribed to engender callus. "If the callus is small let nourishment be drawn to the place by frictions and embrocations and pitch plasters and loose ligature."

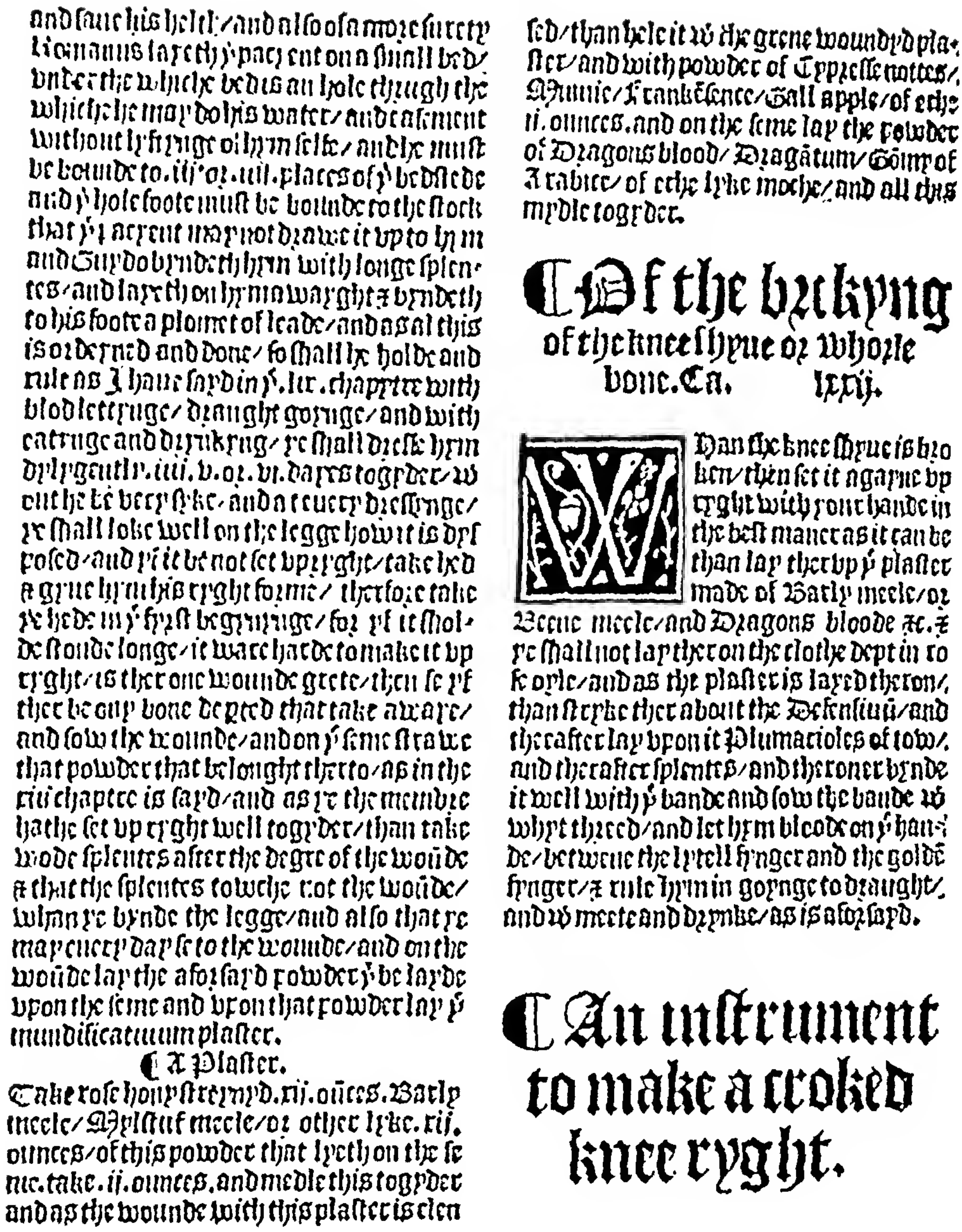
He probably did open reductions after the method of Avicenna, and he often found a weight and pulley useful. His advice concerning fracture of the jaw and of the clavicle was the same as that of Hippocrates. Depressed rib or clavicle fractures were pulled out either by suction with some glutinous substance or with the palm of the hand, or by a hook. Fractures of the humerus were reduced by manual extension; the frag-

ments were immobilized with five or six splints; and the arm was put in a sling. Union was timed at forty days. Regarding the hip, he stated that: "The bone of the hip is scarcely often broken, but it is sometimes split, and its edges are crushed. Sometimes it is pushed into the abdomen, . . . and the fracture is very difficult to reduce." For the thigh, six or seven splints and strong extension were used. He did not approve of a method described by Albucasis in which the leg was bound to the thigh so that the heel touched the buttock. "With regard to myself, the thigh being bound with long splints. . . . I attach to the foot a leaden weight, passing the cord over a little pulley so that it will keep the leg in its proper length. . . ." Union was timed at fifty days. Leg fractures were treated with the same contrivance as for the thigh. He did not recognize fracture of the patella or of the os calcis, but stated that the patella was frequently distorted and should be restored to its shape and held with a round wooden splint. "The heel bone does not break, inasmuch as it is a hard bone protected or covered with ligaments."

In short, we find that Guy de Chauliac used weight traction, suspension, an overhead monkey pole, massage (friction and embrocation) and damming for delayed union, coaptation splints, débridement, and open reduction.

FIG. 2

Anterior and posterior views of fracture of tibia and fibula from an ancient Indian skeleton found in a grave, five feet deep, under a heavy slab of limestone. The skeleton lay face down with arms and legs folded under the body. (From the Southwest Museum, California.)



and saue his helth / and also for a more surety Lionarus sayeth ȳ pacient on a small bed / under the whiche bed is an hole through the which he may do his water / and easement without lyftinge of hym selfe / and he must be bounde to .iii. or .iiii. places of ȳ bedstede and ȳ hole foote must be bounde to the stocke that ȳ pacyent may not drawe it up to hym and Guydo byndeth hym with longe splentes / and layeth on hym a wayght & byndeth to his foote a plomet of leade / and as al this is ordeyned and done / so shall he holde and rule as I haue sayd in ȳ .lx. chapytre with blodlettynge / draught gorynge / and with eatynge and drynkyng / ye shall dresse hym dylygently .iiii. v. or .vi. dayes togyder / w out he be very seke / and at euery dressynge / ye shall loke well on the legge how it is dysposed / and yf it be not set upryght / take hede agyne hym his ryght forme / therfore take ye hede in ȳ fyrst begynnynge / for yf it sholde stonde longe / it ware harde to make it up ryght / is there one wounde grete / then se yf there be ony bone broken that take awaye / and sow the wounde / and on ȳ same strawe that powder that belongeth therto / as in the .xiii. chaptre is sayd / and as ye the membre hathe set up ryght well togyder / than take wode splentes after the degre of the wounde & that the splentes towche not the wounde / whan ye bynde the legge / and also that ye may euery daye se to the wounde / and on the wounde lay the aforsayd powder ȳ be layde upon the same and upon that powder lay ȳ mundificatiuum plaster.

¶ A plaster.

Take rose hony stremyd .xii. ounces. Barly meele / Mylstuf meele / or other lyke .xii. ounces / of this powder that lyeth on the same. take .ii. ounces. and medle this togyder and as the wounde with this plaster is clensed / than hele it w the grene woundplaster / and with powder of Cypresse nottes / Mumie / Frankensence / Gall apple / of eche .ii. ounces. and on the same lay the powder of Dragons blood / Dragantum / Gom of Arabice / of eche lyke moche / and all this medle togyder.

¶ Of the brekyng of the knee shyne or whole bone. Ca. lxxii.

Whan the knee shyne is broken / then set it agayne up ryght with your hande in the best maner as it can be than lay ther upon ȳ plaster made of Barly meele / or Beene meele / and Dragons bloode &c. & ye shall not lay ther on the clothe dept in to oyle / and as the plaster is layed theron / than strype ther about the Defensiuū / and thereafter lay upon it Plumaciolis of towe / and thereafter splentes / and therouer bynde it well with ȳ bande and sow the bande w whyt threed / and let hym bleede on ȳ hande / betwene the lytell fynger and the golde fynger / & rule hym in gorynge to draught / and w meete and drynke / as is aforsayd.

¶ An instrument to make a croked knee ryght.

FIG. 3

A page from "The noble experyence of the vertuous handy warke of surgeri", by Jherome of Bruynswyke, 1525.[6] An old English translation of a German book. (From the rare-book room, The Huntington Library.)

AMBROISE PARÉ (1510–1590)

Paré quoted Hippocrates frequently; some paragraphs were almost literal translations, as, for example, the one on fracture of the femur in which he described extension methods and gave details regarding bandaging. He advised reduction of fracture of the coccyx by internal and external manipulation followed by recumbency. For compound fractures he used splints of shaped metal with notches cut out, so that the wound would be accessible without removing the splint.

In one instance he was called to see a woman with an injury to her hip and, on finding the leg short and the trochanter prominent, he thought it

was a dislocation. He pulled and manipulated the leg until it was the same length as the other. Two days later he revisited the patient and found the leg again short and turned out. On removing the bandages, crepitation was felt. He then reduced the bone and applied splints and bandages "*en croix S. André*" (spica). The patient was confined to the bed with an arc at the foot to keep the bed clothes from pressing on the toes, and a cord was suspended from a beam over the middle of the bed so that she could raise herself with her arms. He described fracture of the patella (a fracture not mentioned by Hippocrates or by Galen) and reduced the fragments by extending the leg. The leg was kept still as though it were broken until the callus was hard. He stated that he had never seen a patient who did not limp after such a fracture because the healed fragments impaired extension of the knee and made it difficult to go upstairs. Union required a long time in bed,—forty days or more.

HIERONYMUS BRUNSCHWIG (1450–1533)

The first important book on surgery to appear in England was a translation [6] of Brunschwig's work which was published in Strasbourg in 1497. It is one of several books on surgery of the fifteenth century, printed in old English type, with quaint spelling and construction, which are to be found at the rare-book room of the Huntington Library, San Marino, California. Brunschwig was a German surgeon of outstanding ability. He quoted Guido de Cauliaco (Guy de Chauliac), Avicenna, and Albucasis frequently in the part of the book which deals with fractures. He seemed to have been a disciple of Guido de Cauliaco, as far as the use of ointments and other applications was concerned. "Yf the flesshe

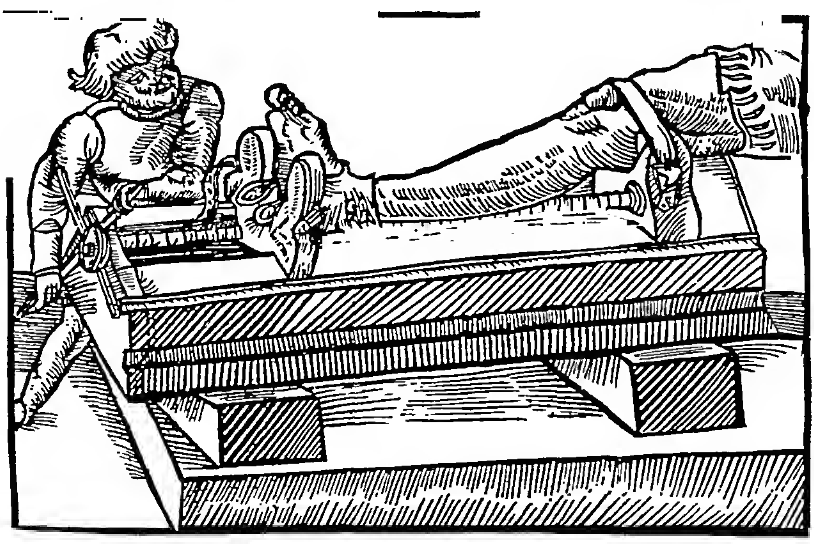


Fig. 4

An instrument to make a crooked knee straight, referred to in the text reproduced in Fig. 3.

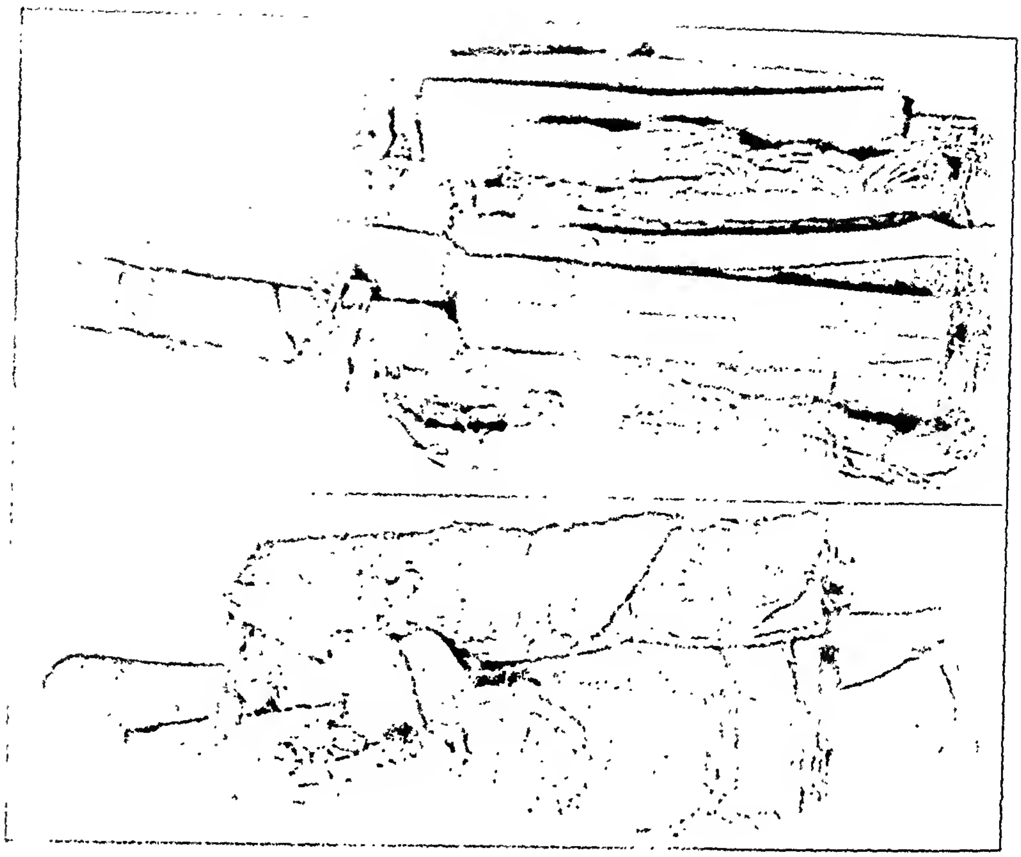


FIG. 5

Two specimens of fracture of the forearm from Egyptian mummies. From the Nubian Collection, Royal College of Surgeons, London. No. 115 (above) shows the unwrapped arm with splints made from the midrib of the palm; No. 116 (below), the outer wrappings of the splinted arm. Both specimens belong to the Pyramid Age of the Old Kingdom, Fourth Dynasty, about 2500 B.C.

be brused with the fracture of the bone then shall the bone be bounde with oyle of roses and shall lay on the powder of myrtylle beryes and over the oyle and powder ye shall lay a cloth depte in the white of egges and oyle of roses and bynde it softely." An uneven break in a bone he called "frustration" and a longitudinal fracture was called "apertura". Splints were made of box or hard wood, or of horn. They must be thicker in the middle than at the end and must not press on the joints. Mechanical apparatus is suggested where he stated that in reduction one pulled down and another up, "but it were very good to have a vyce made therefore tyll the membre be bounde". He advised an abundance of meat in the diet because "theron cometh that conglutinatinum [callus?] that is helynge".

Apparently experimental surgery was done in those days. In order to prove the efficacy of a powder made of "bolarmen, ambra or walderote and small barlye mele" mixed together, a dog's leg was broken and this powder, mixed with white of egg, was laid on the dog's leg which was then splinted. "As ye viij days were past then take the splentes of and the dogges legge was hole."

In compound fractures he advised taking out small pieces of bone. The pain was then taken away by salving with "oyle of roses".

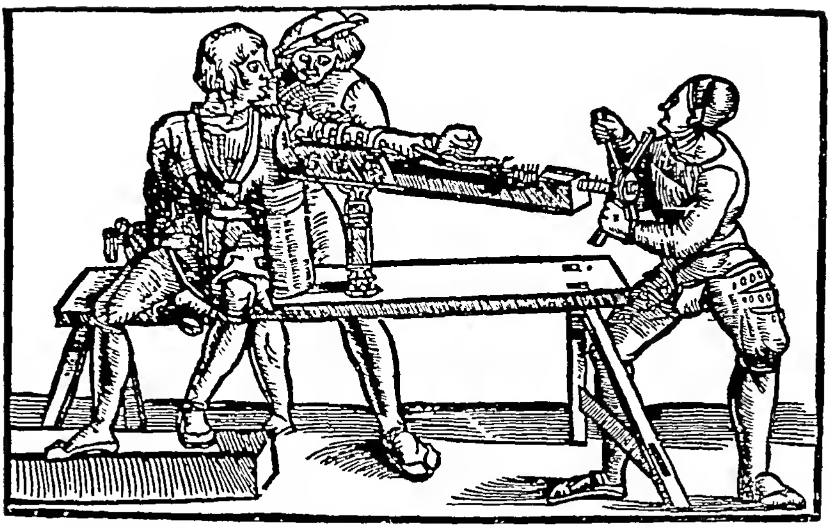


Fig. 6

Mechanical extension of the humerus. From Bruynswyke, 1525.[6] This resembles the glossocomium of Hippocrates. (The Huntington Library.)

Directions were given for reducing a fractured jaw by inserting a finger of one hand in the mouth and by pressing the other hand on the cheek. The teeth were to be braided together with silk thread or fine copper wire to maintain the fragments in approximation. He thought that fracture of the spine seldom occurred, but he recognized paralysis from back injuries, and localized the lesion in a general way by observing what limbs were paralyzed. Agreeing with Albucasis, he said that one should not attempt to cure a patient who had lost contrcl of the bladder

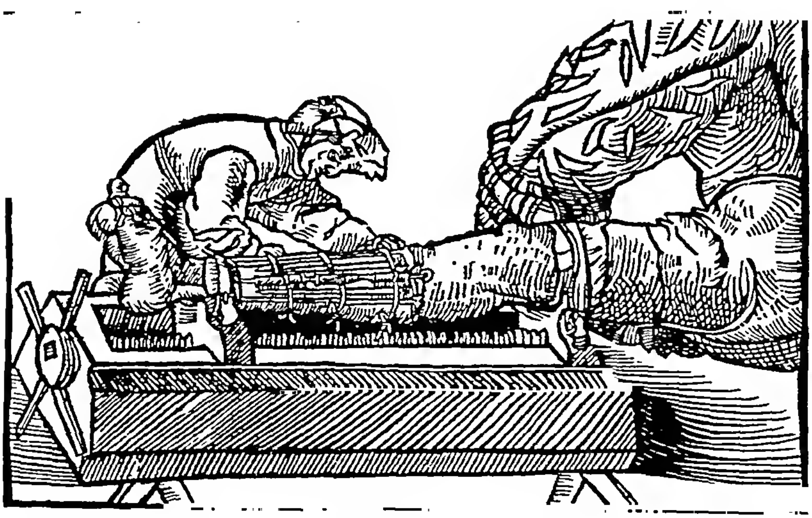


Fig. 7

Mechanical extension and coaptation splints for fracture of the leg. From Bruynswyke, 1525.[6] (The Huntington Library.)

and bowels following a back injury. However, if there was no paralysis he advised the surgeon to "set with your hande the bones and knottes of the back bone as well as ye can and on the fracture lay this plaster: Take cyses meele or beene meel or mylestaffe meele xij ounces, maftik dragatum, gomi arabici of eche two ounces, mumie balyarmeni of eche an ounce and put togyder and make it like a plaster."

Great faith seems to have been placed in these powders. "Maftik" was a much used ingredient. Another powder contained dragon blood. "This powder hath ye power to hele and make stronge the bones and to cause them to growe togyder." He mentions greenstick fractures of the forearm bones. The long bones he sometimes calls "pipes". In the forearm "if both ye pypes be broken so must you have ij servnants, ye one shall holde the paeyent by ye elbowe and the other by the hande . . . set the bone with your hande softely togyder in ye best manner". He cautioned against causing too much pain because it might result in moisture descending into the arm "so myght therof come moch harme".

A fractured finger was laid in an elder-pipe splint and bound together with the sound fingers.

"In the shynne be ii bones, . . . sometyme brekyth the great pype, sometyme the lytel pype . . . the great is more peryllous than the small, and as they bothe be broken that is moost peryl." The splints for the leg must be longer than those for the arm. He admonishes the surgeon not to bind the leg too tight because the "paeyent might come in great harme, payne and fere . . . bynde with clothe depte in oyle of roses". In reducing fractures of the hip and thigh, it is advised that the bone be thrust downward and set again upright.

Although there are several pictures in the book illustrating mechanical methods of extension, Brunschwig scarcely mentions these methods in the text. The absence of reference to Hippocrates is conspicuous.

GIOVANNI DI VIGO (1460–1520)

Another translation into old English is that of a book by Vigo, a surgeon of Italy. He placed much stress on the healing of fractures by external applications of various ointments and concoctions, even going so far as to say that "a broken member . . . can not be duelye restored excepte confoundyng medicines be applied at the beginnyng". Every few days the bandages were to be opened and the limb anointed with "oyle mertyne, actually hoote laying it on with a hen's feather". Another application was "oyle of roses and cammomylle with the decoctyon of earthe wormes". He used splints either of willow wood or made from a sword scabbard, and he stiffened the bandages with egg white. Manual extension was practised, or when necessary a "tortulare" of Hippocrates was used to accomplish reduction. He was an early advocate of emergency treatment of fractures, contending that "the restauratyon of a broken bone . . . must be done as sone as may be". He also cautioned that the comminuted fracture was very dangerous, because the little

pieces pricked the muscles and the flesh. A bone broken lengthwise was much easier to cure than one broken across. The time required for union was as follows: the shoulder, twenty-four days; the humerus, forty days; the arm, twenty-four days; the thigh, fifty days; and the leg, forty days. "The rounde bone of the knee receiveth no fracture, but is dysplaced and putte oute of ioynte."

SIXTEENTH-CENTURY ENGLAND

The earliest books to appear in the English language were translations such as those already mentioned. In the latter half of the sixteenth century, however, the physicians and surgeons of St. Bartholomew's Hospital and of other London hospitals began to record their own observations and experiences. These books are now rare and are available only in the rare-book collections of a few special libraries such as the Huntington Library and the British Museum.

Thomas Gale (1507–1586), who served with the army of Henry the Eighth in France and gained knowledge of broken bones on the battle fields, classified fractures as simple and compound with subdivisions according to their resemblance to stalks of herbs and vegetables, which must have been rather imaginary. His book is written in the form of conversations in which the author answers questions put by John Yates and John Fielde. Compound fractures included not only those with open flesh wounds, but also those which had "one or more effectes to it connected or ioyned" such as gangrene, inflammation, severe contusion, too much callus, or too dry or too moist callus. He used a sort of drill with a conical-shaped bit for enlarging spaces between fragments, so that arrows or other foreign bodies could be removed.

William Clowes (1540–1604), probably the greatest of early English surgeons, wrote a series of detailed case reports. He advocated the use of external applications of powders and ointments. One ointment, for which he gives the formula, contained forty-four ingredients. His account of reducing a fracture of the femur is worth quoting completely: "First I made two decent towels, and fastened each towel one above the fracture and the other below the fracture. Then I caused two strong men to aprehend and take hold of each towel and I placed myself very neare unto the fracture. Then all things being readie I caused them stronglie to extend or stretch out the member; which being suffiently performed I did elevate or lift up that part of the bone which was depressed and agayne I did also depresse downe the other part of the fractured bone which was borne by or elevated; which being reduced and counited together and rightly restored as near as I could according to natures former union, which being then well joyned I did curiously keepe close the dissevered bones together, and then I caused the men which extended the member by little and little to release their hands, whereby the patient found himself greatly eased of his paynes. . . ." The thigh was then wrapped in linen cloth, soaked in egg white and vinegar. Coaptation splints of willow

wood were bound on and the leg was laid in a sort of bed made of "a good quantitie of great rushes", which was similar to "that famous instrument called of the learned Glossocomium". On account of complications he had a consultation with "my approved good friend Maister Banister". Nevertheless, afterward the patient and friends were "somewhat disconcerted and used some words . . . the chief matter was (besides they were loth to part with their monie) only for that the fractured leg was somewhat shorter than the other. I told them agayne that much might be done in young persons which in aged oftentime did not happily fall out." He then cited a case of a boy of ten who had a badly broken thigh, but who grew up to be a strong man without lameness.

Peter Lowe (or *Low*) (1550-1612) has a chapter on fractures in a book written in the form of a dialogue between Peter and John Lowe. In making a diagnosis, he observed whether there were inequalities easily felt, pain on handling, or a "noyse or bruite" on movement. He called attention to the serious nature of fracture of the femur and used extension for reduction, "one at ye nether part the other at ye upper part, of which one draweth up the other down". If the hands were not sufficient, he used cords and if great force was needed he used the glossocomium. Reduction was done by manipulation in addition to the extension. Splints were made of cardboard, wood, or "white iron", hollow in shape. Three splints were necessary,—the longest was applied to the under part of the fracture as a foundation and the other two were placed on the sides. The patient was advised to eat veal, mutton, and kid to make callus. If the position was not good after consolidation had begun, union might be broken up, first fomenting the part for fifteen days with "hennes, goose or cockes grease to soften the caule (callus)". This was regarded as a serious procedure and Lowe was not much in favor of it, saying that "better it is to suffer a little deformity of the part than losse of the whole body".

In case of a fracture which is accompanied by a dislocation, he advised that the dislocation be reduced first, then the fracture. He described an adhesive paste, made of dragon's blood, mafticke incense, saccrocolla, and fine flower and mixed with white of egg, by which cloth could be made to stick to the skin. This was used instead of sutures to hold wounds together, but he does not mention its use for extension.

Stephen Bradwell, in 1633, wrote a book on emergency surgery, but he did not seem to be interested in fractures. From the following quotation it might be inferred that he disdained to do the work which was being done by the bone-setters who were then becoming prominent in England: "But if, in such a fall, any bone be put out of joint or broken, they must get help of such as are skilful in bone-setting, which art is learned by sight and not by writing."

Like many medical books of his time it has a pious note throughout and closes with a prayer: "Thus have I endeavored a common good. And I beseech our Lord Jesus Christ, that either by his Providence they fall not into any of these Accidents, or els by his blessing upon these or the like meanes, they may safely escape them."

John Banester (1533–1610), a famous London surgeon, reduced fractures by manual extension or by means of the glossocomium "which is done like, as by the sentence of a judge, tormentors stretch upon the racke". He recognized the difference between transverse fractures, in which the "bones make a noyse and crackling", and longitudinal ones, where the part is unnaturally thick. Coaptation splints, bound on with bandages dipped in vinegar and egg albumen, seem to have been his usual method of fixation. After fifteen days he loosened the bandages and put on fomentations of wine, salt, and rose oil. This was done thereafter every seven days. "By these meanes shall nature joyne againe the broken bones (like as sometime also without medicine) which she doth by engendering a callous substance betwixt the broken parts, whereby they are glued together againe."

He treated delayed union by application of warm water and friction, and for malunion he advised softening the callus with various medicinal applications, and then breaking it and correcting the deformity. Complications are recorded as "improportionate growth of callus, paine, inflammation, itching, gangrene and uncomely form of the membre". If there was evidence of gangrene, he sacrificed the part affected. His schedule of union was as follows: the leg bones, forty days; the rib, twenty-one days; and the humerus, twenty-seven to forty days.

The method of treatment which seems to have been most prominent in London during the sixteenth century is the external application of medicine to the fractured limbs. This was probably due to the influence of Guy de Chauliac. However, the London surgeons did not employ his extension methods very generally; at least no mention of permanent extension with weight and pulleys is found in their writings. Physiotherapy was used in various forms. In the history of St. Bartholomew's Hospital (founded in 1123) there is mentioned the building of a "hot house for the poor to sweat in" (1555). Fractures were treated as emergencies, as shown by the instructions to the senior beadle that such cases were to be admitted at once.

AMERICAN INDIANS

Among the American Indians, not only the medicine men, but also the laymen were familiar with fractures and their treatment. It is significant that the splints they used were long enough to immobilize the neighboring joints,[20] while those employed by the surgeons of medieval Europe stopped short of the joints. One form of splint was made of wet rawhide, which was pliable. It was shaped to the limb after reduction of the fracture and, on drying, formed a firm, stiff cast.[16]

The Indians also used coaptation splints made of cedar wood. Treatment of a fractured humerus is described by Hoffman. The splint "consisted of twelve or fifteen strips of cedar wood, each of which was about a quarter of an inch thick, three-fourths of an inch wide, and from six to eight inches in length". Near the ends they were held together by

sinews woven between them, making an intact unit which was applied to the arm and held there by tying the sinews together. Enough space was left between the splints for applying soothing lotions and for dressing the wound of the compound fracture. Another method cited was that of splints made of birch bark soaked in water until quite soft.[22] They were then carefully fitted to the limb and tied with bark thongs. On drying, they became stiff and firm. There is no record of the use of extension, but, nevertheless, very few crippled and deformed Indians were to be seen.

According to Andros, a case of compound fracture of the leg, four or five inches above the ankle, was treated as follows: A semicylindrical piece of bark, larger than the limb, was applied to the back of the leg and thigh. It was cut deeply at both sides of the knee, so that it could be bent to an inclined plane. The splint was then filled with soft clay, and the limb was imbedded in it from heel to groin, with the exception of an opening which was left for the wound. "The wound was kept clean and dressed with the thick mucilage of elm bark. The patient made a rapid recovery, with but little shortening."

Specimens of fractured bones have been found in Indian graves of the Southwest. Some of them are united in good position, others with some deformity. The one illustrated (Fig. 2) shows signs of having been infected as well as shortened.

SUMMARY

The high points in civilization which have produced the best in all the arts naturally were the times of greatest achievement in medicine and surgery. If we were to pick out one age and people which shone the brightest in this respect, it would be Greece in the fifth century, and, if one man were to be selected, he would be Hippocrates.

The next age of importance is probably the eleventh and twelfth centuries when the Arabian school flourished, the most prominent member of which was Avicenna.

In the fourteenth century we come to another high point which is brought to our knowledge by the writings of Guy de Chauliac.

Again, in the sixteenth century, Ambroise Paré seems to tower above the others of his time.

The most striking fact encountered in such a study as this is that many of our supposedly modern inventions and methods—some of which bear names of doctors of the nineteenth or twentieth centuries—were discovered and practised 2,000 or 3,000 years ago.

A distinguished scholar[3] once said: "Whenever I get a new idea I look up and see which Greek author had expressed it best."

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SKELETAL AND EXTRASKELETAL TUBERCULOUS LESIONS ASSOCIATED WITH JOINT TUBERCULOSIS

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The purpose of this paper is to analyze the incidence of skeletal and extraskeletal tuberculous lesions as a complication in 555 patients with joint tuberculosis.

Joints are infected with tuberculosis by way of the circulatory system, and the determination of the site of the primary lesion is difficult and often impossible. Many consider the lung the portal of entry. However, various workers, quoted by MacCallum, have shown that tubercle bacilli, brought into contact with any mucous membrane, can be absorbed without leaving a destructive lesion at the point of entrance, and can then spread rapidly throughout the body, lodging in lymphoid tissue and forming a possible focus. If we accept this theory, the nasopharyngeal and the gastro-intestinal mucous membranes must be included as portals of entry.

No attempt has been made to establish the primary source of the tuberculosis in this series of patients. However, in this connection, it is significant that 238 patients (43 per cent.) in this series presented no demonstrable skeletal or extraskeletal tuberculous lesion, clinically or roentgenographically, other than the single joint lesion for which they were originally treated.

NATURE OF THE MATERIAL

The 555 patients studied were treated in the New York Orthopaedic Dispensary and Hospital during the years 1923 to 1933. These patients represented in the main an ambulatory group on their admission to this Clinic and were selected cases only to that degree. Those patients who were very poor operative risks, due to advanced or fulminating pulmonary tuberculosis, were referred to sanatoria, the greater percentage of these being sent to Sea View Hospital. All of the tuberculous joints in this series were arthrodesed and the patients were followed for at least one year after operation, with an average follow-up of four years.

PATHOLOGICAL PROOF OF JOINT TUBERCULOSIS

In 379 of the 555 patients, the tuberculous nature of the joint lesion was proved by one or more of the following methods: microscopic section of biopsy material positive for tuberculosis, 340 cases; positive guinea-pig inoculation of biopsy material, 269 cases; smears of aspirated pus positive for tubercle bacilli, 11 cases. The lesions in the remaining 176 patients, in whom no pathological proof was found, were all in the vertebral bodies. In these patients, the location of the disease was such that pathological

TABLE I

LOCATION OF DISEASE

Site	No. of Patients
Spine	228
Hip	154
Knee	101
Ankle	27
Wrist	19
Shoulder	11
Elbow	8
Tarsus	7
Total	555

material was not available, but the clinical and roentgenographic findings were typical of tuberculosis.

TUBERCULIN SKIN TESTS

The patients were tested either by the von Pirquet or by the Mantoux method. Of the 538 patients for whom there were records, only one gave a negative reaction. The test was repeated three times in this case and each time a negative result was recorded. This patient was a baby, six months old, and the diagnosis of tuberculosis of the spine was as definite as possible in the absence of pathological material for examination. The lungs in this patient also showed evidence of the childhood type of tuberculosis. Therefore, a negative tuberculin test is of great value in excluding the diagnosis of tuberculosis of the bones and joints.

SEX AND DURATION OF SYMPTOMS

An analysis of the sex and age of the entire group showed nothing significant. The sexes were about equally divided, and the ages ranged from seven months to fifty-eight years, with an average age of seventeen years. The average duration of symptoms at the time of admission to the hospital was six years, the shortest duration being two weeks and the longest thirty-three years.

TABLE II

INCIDENCE OF PULMONARY TUBERCULOSIS IN 555 PATIENTS WITH JOINT TUBERCULOSIS

Type of Lesion	Patients	Per Cent.
Active pulmonary or bronchial gland	69	12.43
Inactive pulmonary or bronchial gland	199	35.86
No demonstrable pulmonary lesion	287	51.71

FAMILY HISTORY

Of 299 patients for whom there were records, 26 per cent. gave a family history of tuberculosis. Henderson found a positive family history in 19 per cent. of his cases of tuberculosis of the hip and 9 per cent. in cases of tuberculosis of the knee.

COMMENT ON THE PULMONARY LESIONS

A recapitulation of the pulmonary findings in Table II reveals that 48 per cent. of the patients with joint tuberculosis had pulmonary or bronchial-gland tuberculosis. There were only 12 per cent. in whom the disease was active and 36 per cent. in whom the disease was inactive. The activity or inactivity of the lesions shown in Table II was determined by a correlation of the physical and roentgenographic findings. While sputum examination is one of the positive factors in the determination of the activity of the pulmonary lesion, it was not done in this series of cases. No attempt has been made to classify further the lesions in these patients. However, Reisner studied the pulmonary findings in a somewhat similar group of patients and found "a strikingly large proportion of the discrete nodular disseminated forms of various quantitative extent, ranging from a small number of foci of the abortive type with frequent indications of healing and calcification . . . through various degrees of dissemination of the chronic miliary and acinonodose type . . . to the typical acute miliary tuberculosis". Other writers have found a closely corresponding incidence of pulmonary lesions in groups of patients with bone and joint tuberculosis (approximately 48 per cent.). Löwenstein, in reviewing the post-mortem examinations in 400 cases of skeletal and genito-urinary tuberculosis, found the lungs free from changes or showing insignificant apical scars in 60 per cent. of the patients with skeletal lesions.

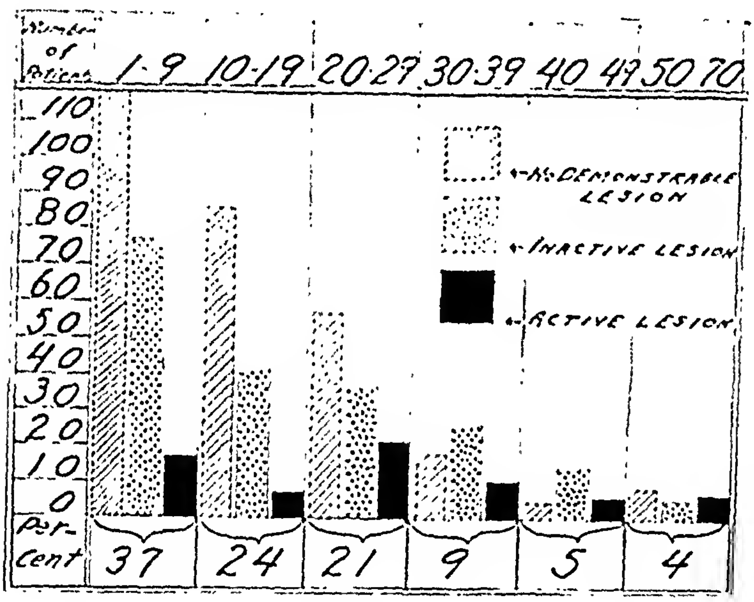

FIG. 1

Incidence of pulmonary tuberculosis according to decades.

Involvement of the lungs with tuberculosis in the respective age groups of this series is shown in Figure 1. The proportion of patients with inactive pulmonary tuberculosis and of those with no demonstrable

pulmonary lesion is very high in the first two decades of life, while the proportion of patients with active tuberculosis is much greater after the second decade. An explanation of this variation is that the primary lesion is probably in the lymphoid tissue in a greater number of cases in the first two decades of life, while after that period the general incidence of pulmonary tuberculosis increases.

The pulmonary tuberculous lesions associated with joint tuberculosis in this series were relatively benign in character. The significant finding which demonstrated the benign nature of the pulmonary lesion was the comparatively low percentage (12.0) of patients with active pulmonary tuberculosis.

The benign nature of the pulmonary lesion is also demonstrated in Table III. Retrogression or healing of the pulmonary lesion (active or inactive) frequently occurs after treatment of the joint lesion by operative fusion. In only ten patients could the pulmonary disease be considered as progressing. These ten patients include the nine who died of pulmonary tuberculosis (Table V) and the one who developed active pulmonary tuberculosis following a spine fusion, when the original examination of her lungs was negative (Table III).

The benign nature of the pulmonary lesion cannot be considered as the only cause of the retrogression of the disease. Rest in bed, following operative fusion of the diseased joint, and the consequent healing of the local focus improved the patient's general health. The healing of the pulmonary lesion must be considered to be due in part to elimination of the joint focus following operative procedures, for a large proportion of patients in the active pulmonary group had sanatorium treatment or rest in

TABLE III

COMPARATIVE STATUS OF PULMONARY LESIONS ON FOLLOW-UP EXAMINATIONS

On Admission			On Follow-Up Examinations							
			Active		Inactive		No Demonstrable Lesion		Deaths	
Pulmonary Status	Cases	Per Cent.	Cases	Per Cent.	Cases	Per Cent.	Cases	Per Cent.	Cases	Per Cent.
Active tuberculosis......	69	12.43	7	10.14	40	57.97	0	0.00	22	31.89
Inactive tuberculosis......	199	35.86	0	0.00	187	93.97	0	0.00	12	6.03
No demonstrable lesion............	287	51.71	1	0.35	0	0.00	275	95.82	11	3.83
Total..........	555	100.00	8	1.44	227	40.90	275	49.55	45	8.11

bed at home under the care of a physician before their joint lesions were treated surgically.

Operative procedures are not attempted either in children or in adults in whom the pulmonary disease is far advanced or when the patient is markedly undernourished. Ethylene anaesthesia is now used almost exclusively for patients with any tuberculous lesion, as we feel it is the safest from all standpoints for this class of patients. The author does not believe that the presence of mild or moderately advanced pulmonary tuberculosis in any patient should deter one from operating on the tuberculous joint lesion. For those patients who are undernourished a short period of building up is recommended before operative procedures are attempted.

INCIDENCE OF TUBERCULOUS TONSILS

From 100 patients the tonsils were removed and examined microscopically. A single section was made through the most suspicious area of each tonsil and in twenty-four cases it was found to be tuberculous. Serial sectioning might have revealed a higher incidence of tuberculosis. Neither guinea-pig inoculation nor staining for tubercle bacilli was attempted. Snyder reported an incidence of 5 per cent. of tuberculosis of the tonsils in 100 patients with proved bone and joint tuberculosis. Pathological reports of over 30,000 tonsillectomies on unselected patients, collected from the literature,* show the incidence of tuberculosis to average only 2.8 per cent.

The tuberculous tonsils presented no ulcerations or other characteristic external features which would suggest a diagnosis of tuberculosis before or after their removal, except occasionally a firm nodule was palpable postoperatively in the gross specimen.

Healing followed the tonsillectomy equally well whether or not the tonsils proved tuberculous. Absence of gross pathological changes and good healing power after tonsillectomy have been noted by almost all writers on tonsillar tuberculosis.

Ten (42 per cent.) of the twenty-four patients with tonsillar tuberculosis also had pulmonary tuberculosis. Of these, two had active pulmonary tuberculosis and eight inactive. This percentage of pulmonary tuberculosis associated with tuberculosis of the tonsils is about the same as that which occurred in the whole group of 555 patients, or 48 per cent.

The indications for tonsillectomy in this group were hypertrophy, obstruction of the pharynx, and recurrent attacks of tonsillitis or cervical adenitis.

Removal of the tonsils (tuberculous or non-tuberculous) in this series had no apparent effect on the healing of the joint lesion or on the appearance of multiple tuberculous foci. The tuberculous tonsil, as demonstrated, is a relatively benign lesion. However, as the tonsils are another

* See *References:* Korns, MacCready and Crowe, Mitchell, Morris, Mullin, Rhoads, Welch, Weller, and Wilkinson.

TABLE IV

Incidence of Tuberculous Lesions Associated with Joint Tuberculosis

Associated Tuberculous Lesions	Joint Primarily Diseased							Total (*Cases*)
	Spine (*Cases*)	Hip (*Cases*)	Knee (*Cases*)	Ankle (*Cases*)	Tarsus (*Cases*)	Wrist (*Cases*)	Shoulder (*Cases*)	
	38	25	14	7	2	2	3	91
Hip	11		3	2				16
Kidney	7	3	2	1				13
Sacro-iliac joint	4					1		5
Knee	2	1		1				4
Sternum	2							2
Shoulder	4							4
Peritoneum	2	1						3
Tendon sheaths	1	3	1		2	1		8
Epididymis	1		1	1				3
Greater trochanter	1							1
Metatarsophalangeal joint	1							1
Fallopian tubes	1	1				1		3
Tonsils	8	8	4	2	1		1	24
Spine		6	2	2	1	1	1	13
Ischium		1						1
Wrist		1			1			2
Tarsus		1	1					2
Tibia		1	1					2
Ankle		1			1			2
Metacarpophalangeal joint		1						1
Liver		7						7
Skull				1				1
Skin tuberculides			1	1				2
Digits				1				1
Caecum							1	1
Femur			1					1
Total	45	36	17	12	6	4	3	123

TABLE V

CAUSE OF DEATH IN RELATION TO PULMONARY DISEASE

Cause of Death	Status of Pulmonary Lesion on Last Examination			Total
	Active	Inactive	No Demonstrable Lesion	
Pulmonary tuberculosis	7	2		9
Miliary tuberculosis	9	1	2	12
Tuberculous meningitis	2	3	1	6
Amyloidosis	1	1	1	3
Pulmonary hemorrhage	1			1
Pneumonia	2	3		5
Shock		2	1	3
Pulmonary embolus			2	2
Acute nephritis			1	1
Carcinoma of stomach			1	1
Carcinoma of throat			1	1
Cause unknown			1	1
Total	22	12	11	45

possible tuberculous focus and are found to be involved in a high percentage of patients with joint tuberculosis, their removal is recommended where feasible and certainly in those cases in which the patients' general health is poor.

INCIDENCE OF GENITO-URINARY TUBERCULOSIS

In this series, there were thirteen patients (2 per cent.) with known tuberculosis of the kidney, and three patients (0.5 per cent.) with tuberculous epididymitis. Nephrectomies were done in all cases of tuberculous kidney except three.

The incidence of tuberculous lesions of the genito-urinary system is not high, but careful periodic examinations of the urine are certainly in order as a means of recognizing another possible tuberculous focus. Urine which contains red and white blood cells in a catheterized specimen should be stained for tubercle bacilli, and a guinea-pig inoculation should be made. Harris reported only one case of renal tuberculosis over a ten-year period in 392 patients with bone and joint tuberculosis. However, in a subsequent eighteen-month period, when careful periodic examinations of the urine were made, 13.8 per cent. of the patients were found to have an associated renal tuberculosis.

MULTIPLE TUBERCULOUS FOCI

Ninety-one, or 16 per cent., of the 555 patients had 123 associated skeletal and non-skeletal tuberculous lesions other than pulmonary disease (Table IV). Of this particular group, twenty-one patients (23 per cent.) had active pulmonary tuberculosis; forty-two (46 per cent.) had inactive pulmonary tuberculosis; and twenty-eight (31 per cent.) showed no evidence of pulmonary involvement. This is a greater proportion (69 per cent.) of pulmonary disease than was evidenced in the whole group.

In the seven patients who had tuberculosis of the kidney associated with tuberculous spondylitis, the vertebral lesions were localized in the lower dorsal or lumbar vertebrae, with the majority at the dorsolumbar junction.

Intestinal and laryngeal tuberculosis were rarely encountered in this group of patients. Pagel has noted that laryngeal and intestinal involvement is much more frequent in association with isolated pulmonary lesions than with pulmonary changes which are associated with other extrapulmonary manifestations.

Amyloidosis was encountered as a complication in seven patients, all of whom had tuberculosis of the hip with sinus formation. Three of these patients died of amyloidosis.

MORTALITY STATISTICS

The forty-five deaths (8 per cent.) in this series (Table V) will compare very favorably with a similar group of patients treated by conservative means. In a similar conservatively treated group of tuberculous knees reported by Hibbs and von Lackum, the mortality was 9 per cent.; and, in a group of tuberculous hips reported by Smith and Watters, the mortality was 24 per cent. Cleveland reported a mortality of 28.5 per cent. in a group of 210 patients whose joint tuberculosis was treated surgically, while in a group of slightly over 300 cases, which were rejected as unsuitable for surgery, the mortality was over 80 per cent.

Cleveland's statistics are appalling and no doubt are due to the type of patient treated at Sea View Hospital. In regard to these patients he stated: "Coming from the lower classes of society, from poverty and disease, of less fit racial strains, they have been discarded by most of the city's hospitals and sent to Sea View Hospital for ultimate disposal."

Therefore, the true mortality rate in surgical tuberculosis is probably a mean between Cleveland's finding of 28.5 per cent. and that of 8 per cent. in this series.

As one would expect, the greatest number and percentage of deaths was in the group of patients with active pulmonary tuberculosis. The two most common causes of death in this series were pulmonary and miliary tuberculosis. Reisner, in his review of the literature, brings out the point that acute generalized miliary tuberculosis is rare in chronic pulmonary lesions, whereas in extrapulmonary lesions the opposite seems to be the case. This fact, as also noted in this series, is a further indication that the

pronounced tendency to generalization constitutes a distinct characteristic of the extrapulmonary lesions.

COMMENT

In this study it was found that 317 patients (57 per cent.) had tuberculous skeletal or extraskeletal lesions associated with joint tuberculosis. This determination reminds one that tuberculosis is a systemic disease and that the various manifestations of this infection cannot be considered as separate entities.

Tuberculous joints are disabling, and distressing deformities occur. Operative fusion of these joints is now accepted by most surgeons as the best method of hastening and effecting a satisfactory cure.

Among the main objections to operative fusion has been the erroneous belief that there is an increase in the mortality and a greater dissemination of the disease. The mortality rate of 8 per cent. in this series of operative cases over a postoperative period averaging four years is as low as the mortality rates reported in patients treated by conservative methods. While a likelihood of disseminating the disease sounds plausible, it cannot be proved. The multiple lesions which are a characteristic of the extrapulmonary form of tuberculosis occur in any series. The incidence of multiple lesions (only 16 per cent.) in this series (excluding pulmonary disease and deaths) is not high. Therefore, dissemination is not a common postoperative factor or complication as the result of operation on tuberculous joints.

SUMMARY

1. Of this series of 555 patients with joint tuberculosis, the diagnosis was proved in all but 176 in whom the disease was localized in the vertebral bodies.

2. Active pulmonary tuberculosis was found in 12 per cent. of the patients, inactive in 36 per cent., and no demonstrable lesion in 52 per cent.

3. In this series pulmonary lesions, when associated with joint tuberculosis, were relatively benign in character.

4. Tuberculosis was found in 24 per cent. of the tonsils removed.

5. Only one negative tuberculin test was found in this series of patients. Therefore, a negative tuberculin test is of great value in excluding the diagnosis of tuberculosis of the bones and joints.

6. Tuberculous disease of the genito-urinary tract was found in 2.5 per cent. of the patients.

7. Ninety-one, or 16 per cent., of the patients in this series had 123 associated tuberculous lesions other than pulmonary disease.

8. The mortality rate was 8 per cent. (forty-five patients) in this series.

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BONE ATROPHY AND ABSORPTION

Experimental Observations

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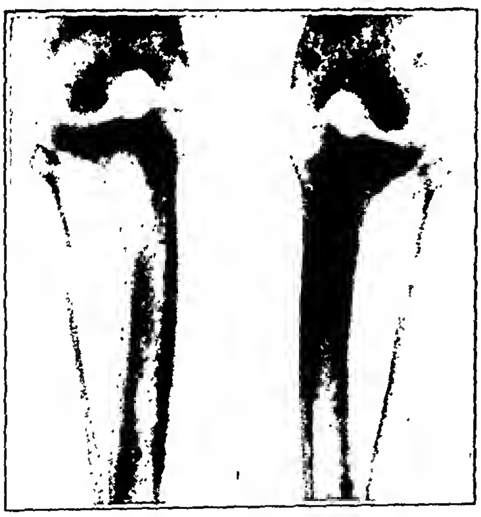
While studying experimentally the influence of circulatory changes on the repair of fibular defects which were made by subperiosteal resections and simple osteotomies in dogs, the author found an unexpected and high incidence of non-union and atrophy of fibular fragments. Not only did decalcification occur in the ununited fibular fragments, which was evidenced by a definite decrease in roentgenographic density, but actual absorption of the fragment ends, as well as concentric absorption of the fragment shafts, was noted.

EXPERIMENTAL WORK

Forty-eight healthy adult dogs were used and aseptic operative technique was employed. In twelve of these dogs, infections of the operative wounds developed and the animals were discarded, leaving thirty-six dogs for study. In twenty-two of these animals, fibular fragments, measuring approximately one and five-tenths millimeters, were resected subperiosteally from near the upper ends of both fibulae. Unilateral lumbar sympathectomy, including usually three and sometimes four



Right Left

FIG. 1-A

Dog 147. R[illegible] taken immediately [illegible] showing the amount of bone removed subperiosteally at the time when a left lumbar sympathectomy was done.

Right Left

FIG. 1-B

Dog 147. Roentgenograms showing the condition eleven months after operation. Note the atrophy and absorption of the fragment ends and the marked concentric atrophy of the fibular fragments throughout the entire length.

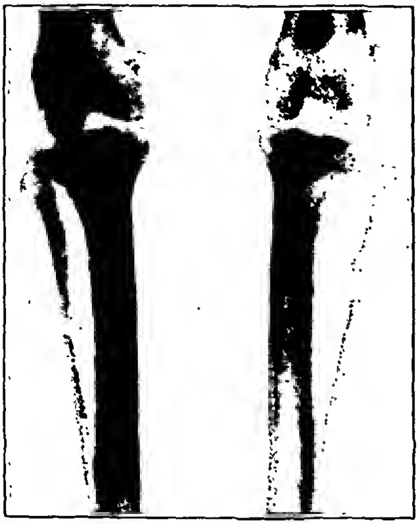


FIG. 2-A

Dog 483. Roentgenograms, taken sixteen days after operation, showing the amount of bone removed at the time of a right femoral-vein ligation.

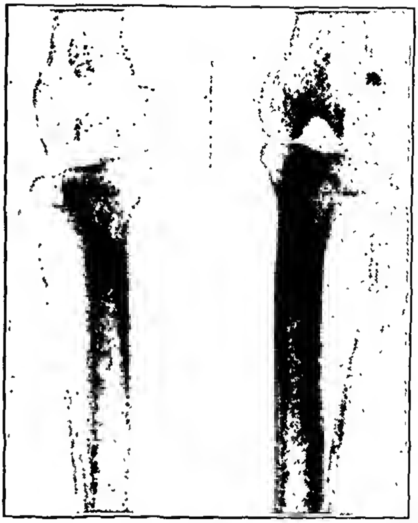


FIG. 2-B

Dog 483. Roentgenograms, taken five months after operation, showing bilateral absorption and atrophy of the fibular fragments. Note the sharp pointing of the latter.

ganglia with the intervening chain from the sacral promontory upward, was performed on twelve of the twenty-two animals. Five had unilateral ligation of the femoral vein in the proximal portion of the thigh, while two had unilateral arterial ligations in the same location. In the remaining three cases, the sciatic nerve was severed in the proximal part of the thigh.

A simple linear subperiosteal osteotomy, near the upper ends of both fibulae, was done in the other fourteen animals, using small bone-biting forceps. Of these, six had unilateral lumbar sympatheetomy and eight had unilateral ligation of the femoral vein in the proximal part of the thigh.

EXPERIMENTAL RESULTS

In nine, or 41 per cent., of the twenty-two dogs from whieh fibular segments were removed subperiosteally, healing failed to take plaee bilaterally; in addition, the ends of the fibular fragments showed absorption. Six of these had had sympatheetomies (Figs. 1-A and 1-B), while three had had venous ligations (Figs. 2-A and 2-B). In one case in the latter group, there resulted non-union and marked absorption on the non-ligated side and a fibrocartilaginous union on the ligated side.

Absorption was marked in some of the eases. The fragment ends became sharply pointed and the fibular defeet, whieh at first measured approximately one and five-tenths millimeters, increased to nearly one centimeter in some eases and more in others. (See Figures 3-A and 3-B.)

In the three dogs that had seiatie-nerve seetions, as well as in the

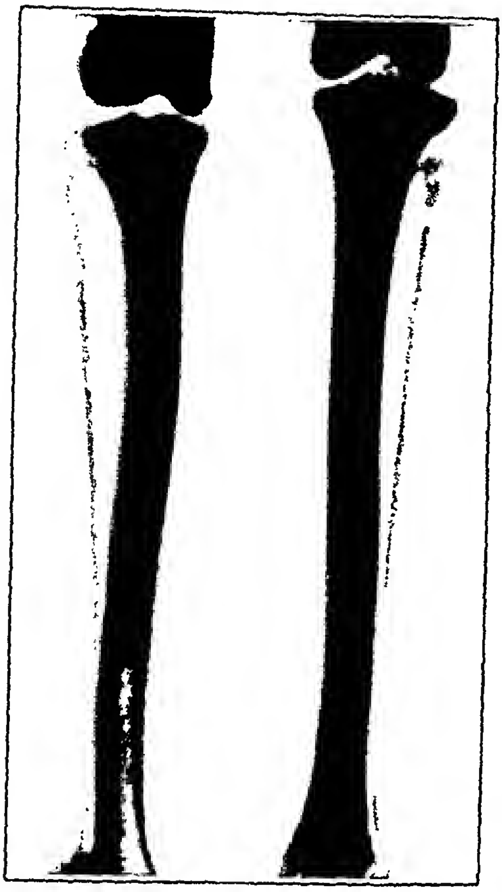


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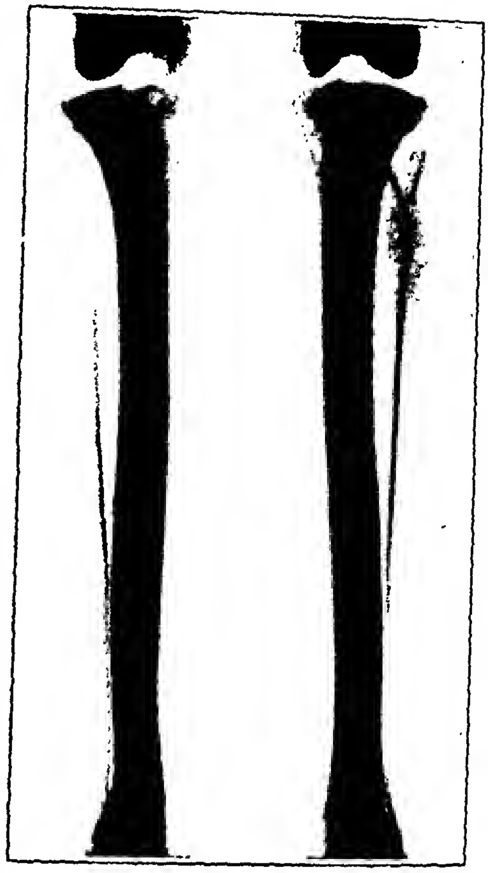
FIG. 3-A

Dog 48. Roentgenograms showing the fibulae three weeks after subperiosteal bone resections and lumbar sympathectomy had been done.



Right Left

FIG. 3-B

Dog 48. Roentgenograms taken six months after operation. Marked bone atrophy and absorption of the fibular fragments are present. Note especially the marked pointing of bone ends and the width of the fibular defects.

two with arterial ligations, bilateral healing resulted. Of the fourteen animals that had had bilateral *simple osteotomies*—six with unilateral sympathectomy and eight with unilateral venous ligation—only one showed non-union, atrophy, and absorption; in the other cases bilateral healing occurred. The animal exhibiting non-union had a right femoral-vein ligation and union occurred on this side, but not on the opposite side.

Experimental results obtained in this series of forty-eight dogs are shown in Tables I and II.

PATHOLOGICAL OBSERVATIONS

Microscopic studies were made of the fibulae in the cases in which union resulted, and the usual picture of true bony callus was seen. Sections were made across the gap between the fragment ends in those cases in which healing did not occur. These ends were often sharply pointed or serrated, and the gap was filled by fibrous and muscular tissue. Osteoclastic lacunar absorption by giant cells was noted at the bone ends and on the cortical surfaces. (See Figure 4-A.) In addition to this there

TABLE I

Bilateral Fibular Segments (1.5 Millimeters) Resected

Procedure	End Results			Total (*Dogs*)
	Infected and Discarded (*Dogs*)	Healed (*Dogs*)	Non-Union (*Dogs*)	
Unilateral lumbar sympathectomy..................	7	6	6*	19
Unilateral femoral-vein ligation....................	0	2	3*†	5
Unilateral femoral-artery ligation....................	0	2	0	2
Unilateral sciatic-nerve section....................	0	3	0	3
Total................	7	13	9	29

* With atrophy and absorption of ends of fragments.

† One of these showed fibrocartilaginous union on the ligated side, but non-union with atrophy and absorption on the opposite side.

was absorption by mononuclear cells, without any evidence of giant-cell osteoclasts, both at the bone ends and on the cortical surfaces. (See Figure 4-B.) The marrow spaces revealed more than the usual amount of hyperaemia, which was marked in several places. In some regions engorged blood vessels were closely approximated to serrated bony surfaces. There was neither gross nor histological evidence of infection.

TABLE II

Bilateral Fibular Osteotomies

Procedure	End Results			Total (*Dogs*)
	Infected and Discarded (*Dogs*)	Healed (*Dogs*)	Non-Union (*Dogs*)	
Unilateral lumbar sympathectomy.................	4	6	0	10
Unilateral femoral-vein ligation...................	1	7	1*†	9
Total................	5	13	1	19

* With atrophy and absorption of ends of fragments.

† This animal showed healing on the ligated side, but not on the opposite side.

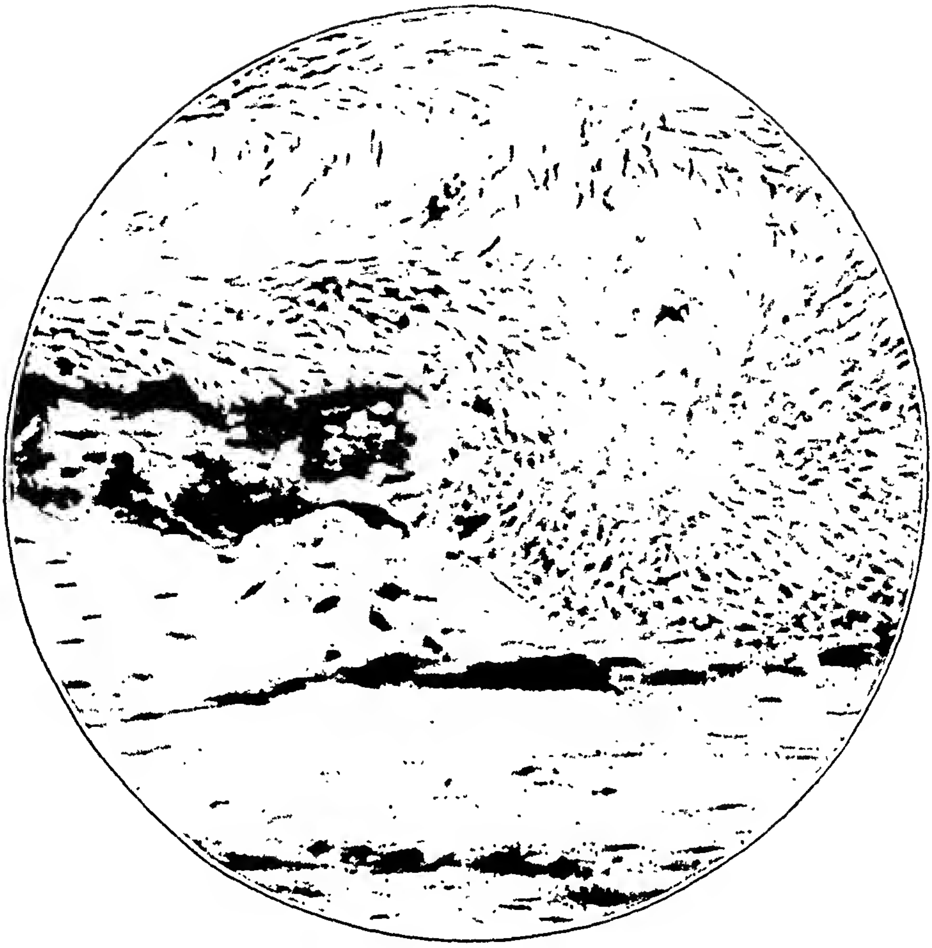


FIG. 4-A
Serration at end of fibular fragment, showing giant-cell osteoclasts producing lacunar absorption.

It is interesting that bone absorption was noted microscopically, not only at and near the fragment ends, but also at a considerable distance from them; this explained the concentric shaft atrophy seen roentgenographically.

COMMENT

In thirteen of the twenty-two dogs with resected fibular segments bilateral healing took place, and in all but one of the remaining nine cases bilateral non-union resulted. Of the fourteen dogs with simple osteotomies all except one showed bilateral bony union. Since nearly all of the cases exhibited either bilateral healing or bilateral non-union, in spite of the accompanying unilateral procedures of sympathectomy, or venous or arterial ligation, or sciatic-nerve section, these factors with their associated circulatory changes had no appreciable influence on the resulting non-union. Also these factors had no demonstrable influence either on the degree or on the rapidity of bone atrophy.

In every case that exhibited a marked degree of bilateral absorption of fragment ends a segment of each fibula had been resected. In one of

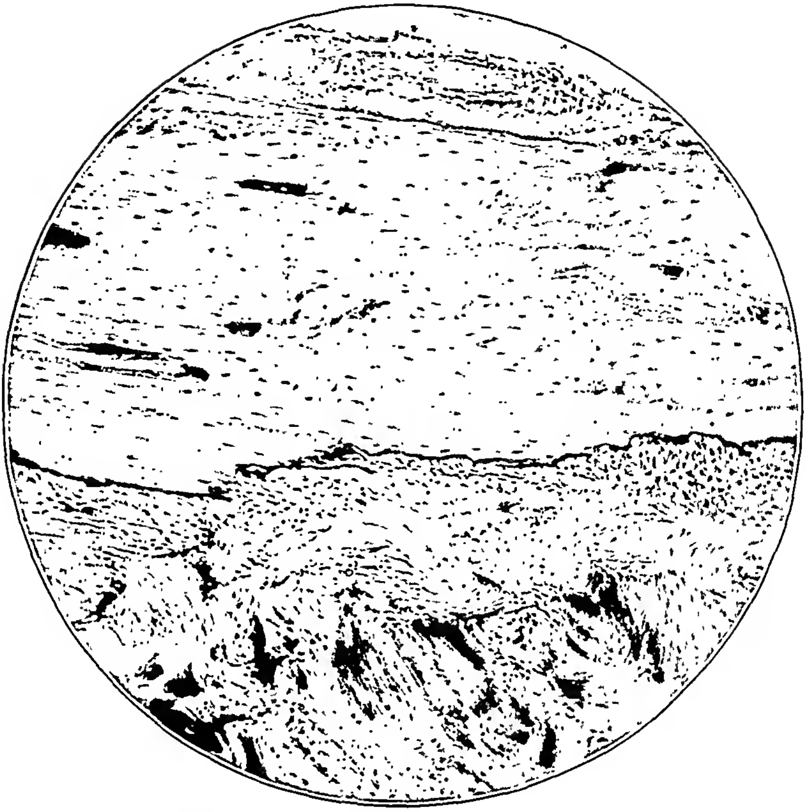


FIG. 4-B
Cortical absorption by mononuclear cells seen at cortical margin.

the fourteen cases in which bilateral simple osteotomies were done, there was non-union with absorption of fragment ends on one side.

A review of the causes leading to non-union of fractures in man reveals a number of factors. Some writers, such as Nutter, have stated that constitutional causes are more numerous than local factors in the prevention of union. Campbell, in discussing the etiology of non-union, states that the causes are both constitutional and local, but not more than 1 per cent. can be attributed to constitutional factors. Among the most important local causes of non-union are: (1) non-apposition of the fractured ends, whether due to loss of bone, to overriding, or to overpull; (2) interposition of the soft parts; (3) infection or neoplasm; (4) faulty immobilization; and, perhaps, (5) circulatory disturbances. Steindler, in commenting on bone regeneration mentions that callus may be stimulated by slight displacement and mobility, also by friction and mechanical and static irritation. However, he mentions that an abnormal amount of mechanical irritation, such as an excess of motion and of physical forces, acts destructively on callus formation.

All but one of the cases of non-union occurred in those animals in which fibular segments had been removed, despite the fact that there was

a continuous bridge of periosteum between the fragments. The author does not offer the above evidence in refutation of the classic experimental studies of Syme and Ollier or of the numerous subsequent investigations in which the osteogenetic properties of periosteum were demonstrated by the occurrence of healing when subperiosteal portions of bone had been removed. The explanation of non-union in these experiments seems to be non-apposition of fragment ends with removal of stress and strain, or incomplete immobilization (these animals were ambulatory and unsplinted), or the possibility of interposition of soft parts, or a combination of these factors. Microscopic studies of the cases in which non-union resulted showed fibrous tissue and muscle filling the defect between the bone ends. A gradual obliteration of the periosteal tube, largely by displaced or hypertrophied surrounding tissues, would be expected in the absence of ossification of the defect. Thus, it is not logical to attribute the non-union primarily to interposition of soft parts.

BONE ATROPHY

In the foregoing experiments that resulted in non-union, a progressive absorption of the fragment ends and a definite decrease in the roentgenographic density of the fibular fragments were seen. A concentric atrophy of the remaining fibular segments was marked in some cases. (See Figures 1-A and 1-B.)

Much has been written in regard to the causes and classification of bone atrophy. Acute post-traumatic bone atrophy was first described by Sudeck in 1900 and, as a result of his observations and more recently of those of Beck, Noble and Hauser, Fontaine and Herrmann, Gurd, and others, it is now accepted by many as a clinical entity. This is a relatively rare condition which follows either severe or relatively slight trauma, often to the ankle, wrist, or knee. Gurd, after a careful review of the literature and the study of his own fourteen cases, summarized the condition as follows: "Acute bone atrophy . . . exhibits typical clinical and radiological appearances. In a very small percentage of cases acute marked osteoporosis occurs within a short time following injury [usually a few days or weeks]. Pain is a predominant factor together with extreme loss of function. Swelling and evident atrophy of the skin and subcutaneous tissue are characteristically present. The condition follows, as a rule, more or less trivial injuries, particularly in the neighborhood of joints, and more especially in the neighborhood of ankle- and wrist-joints. Pathological studies prove a uniform loss of bony substance." Gurd also states that the "röntgenograms show a very typical patchy (*fläckich*) or 'moth-eaten' appearance of the bones in the immediate vicinity of the traumatized area and, also, in the bones distal to the region which has apparently been hurt". Sudeck in his later writings stated that he believed that the condition was due to a trophoneurotic phenomenon. Gurd, as well as Fontaine and Herrmann, considers that the condition is due to a stimulation of the reflex arc with consequent local hyperaemia,

producing bone absorption. These authors refer only to a change in local hyperaemia and do not distinguish between an active and passive hyperaemia, in which, at least in experimental studies, there is a difference both in blood chemistry (McMaster) and in the ability of bone to repair (Pearse and Morton, and McMaster and Roome).

ATROPHY OF DISUSE

Much clinical and experimental evidence has been accumulated to demonstrate that, when a part is put at rest, atrophy of bone occurs in direct proportion (up to reasonable limits) to the amount of disuse. Legg, in studying the cause of atrophy in joint disease, infected various joints in rabbits. He noted that the atrophy either from immobilization and infection or from immobilization alone was much greater than that from infection alone. In studying bone atrophy associated with both infected and non-infected fractures, Blake concluded that the degree of atrophy depends more on disuse than on infection. Likewise, Grey and Carr and Allison and Brooks demonstrated in rather extensive and conclusive experiments that bone atrophy definitely follows disuse. In their experiments on rabbits and dogs, one extremity was used for control; in the other, disuse was brought about by: (1) sectioning the motor nerves, (2) fixation in a plaster-of-Paris cast, and (3) resection of the proximal end of the humerus with a resultant flail joint. Grey and Carr also studied the effects of circulatory changes on the bony parts. They concluded that local venous congestion does not lead directly to any recognizable changes in the structure of bone and that local anaemia due to impairment of the arterial supply, unless it is extreme, likewise occasions no bone atrophy as long as the part remains functionally active. To study the effect of immobilization alone on bone atrophy in clinical cases, Key, Fischer, and Elzinga selected hospital patients and studied the effects of disuse brought about by the application of plaster-of-Paris casts on normal lower extremities. They found that immobilization with or without surgical intervention or manipulative procedures caused atrophy of the bones.

Murphy and Phemister showed that when bone is transplanted to muscle and to other soft parts, although the surrounding blood supply may be rich, the transplanted bone lacks the normal stimulus of function and is absorbed.

With the advent of non-union in the experiments outlined in this paper, the fibular fragments underwent atrophy of disuse, apparently from the lack of the normal stress and strain of weight-bearing and bony continuity, even though the fibula has little weight-bearing function. Muscle attachments were still present, and the bone atrophy indicates that an active circulation existed. These fragments seemed to be undergoing the same fate of returning to soft tissue as did the bone transplants of Murphy and Phemister. The atrophy did not follow plaster immobilization, as none was used; nor did inactivity of the limb influence the result,

for these animals were ambulatory and had the usual freedom of the laboratory.

Of especial interest is the fact that, of the ten animals in which non-union with associated atrophy occurred, eight exhibited bilateral absorption which was practically equal on the two sides despite the fact that operative procedures had been performed which caused a unilateral change in circulation. Two of these dogs had had unilateral femoral-vein ligation with its resultant passive hyperaemia, while six had had unilateral lumbar sympathectomy with its resultant arterial hyperaemia. Neither procedure occasioned any demonstrable difference in the bone atrophy. Hence the atrophy seems due specifically to disuse.

Microscopic studies of the atrophic fibular fragments revealed that in the most active areas bone was being destroyed by giant-cell osteoclastic lacunar absorption. (See Figures 4-A and 4-B.) In addition to this, there was a considerable amount of smooth and slightly serrated absorption produced by mononuclear cells. This was seen especially in the haversian and perforating canals containing blood vessels and fibrous marrow. Also cortical surfaces and fragment ends frequently showed a similar process without evidence of giant-cell osteoclasts, despite careful examination of numerous microscopic sections.

SUMMARY

1. The experimental evidence presented shows that in the presence of non-union of short fibular defects an associated conical bone atrophy, which in some cases was extreme, occurred in the fragment ends. The bone was removed both by lacunar absorption, produced by giant-cell osteoclasts, and by smooth absorption, produced by mononuclear cells. The atrophy is explained on the basis of disuse, caused by an interrupted bony continuity, which resulted in a lack of functional stimulus.

2. When atrophy and absorption of bone ends occurred it was bilateral in practically the same degree and rate despite the fact that on one side there was a circulatory change, produced either by lumbar sympathectomy or by vein ligation. Hence circulatory changes (arterial hyperaemia or venous congestion) *per se* had no essential effect on bone atrophy or on absorption.

3. Non-union occurred in seventeen of forty-four subperiosteal fibular defects (one and five-tenths millimeters), despite the presence in each case of an intact periosteal tube which bridged the defect. This failure of union is explained by non-apposition and excessive motion of the fragment ends, for in twenty-eight linear subperiosteal osteotomies in fibulae where the fragment ends were opposed only one case of non-union occurred.

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KÖHLER'S DISEASE OF THE TARSAL SCAPHOID

An End-Result Study

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This is an analysis of forty-five cases of Köhler's disease, treated at the Children's Hospital, Boston, during the past ten years. Roentgenograms showing complete healing and return to normal bone structure are available in nineteen cases.

An additional study has been made of the normal development of the scaphoid in roentgenograms, taken at six-month intervals, of children from nine months to four years of age.* Certain interesting facts were brought out in this study in relation to Köhler's disease.

Our data are not sufficiently complete to be presented in favor of a developmental etiology of Köhler's disease, although there is probably more to substantiate this theory than any of those that have been previously considered. However, certain clinical facts may be deduced from the tabulated data, and the diagnosis, prognosis, and treatment may be simplified.

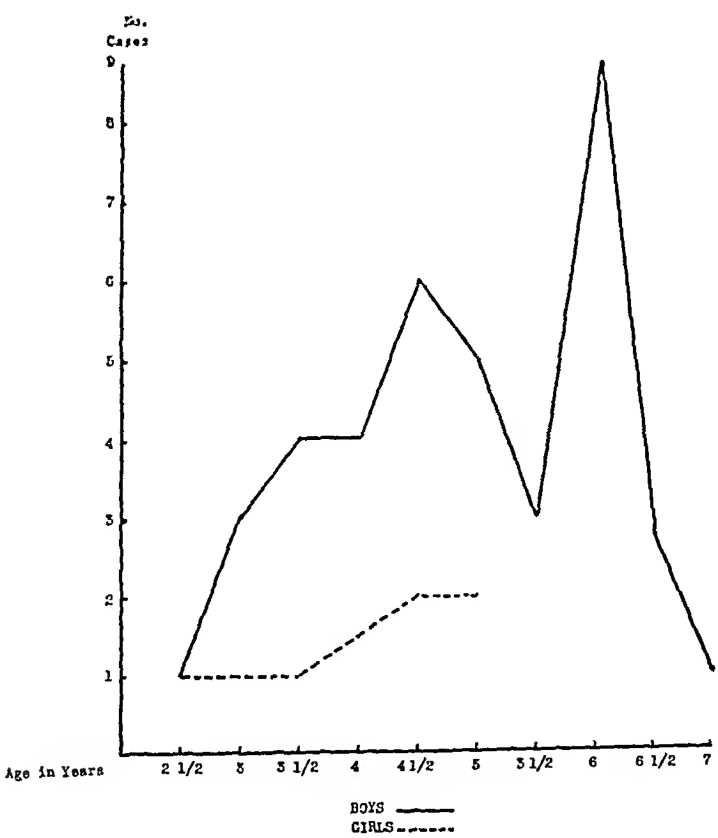


Fig. 1

Incidence of Köhler's disease at various age periods.

ANALYSIS OF DATA

In the present series, there were thirty-nine males and six females, a proportion of 6.5 to 1. The left foot alone was involved in twenty cases; the right, in sixteen; and there was bilateral involvement in nine. All of the bilateral cases were in males.

The age of the youngest patient was two years and six months and that of the oldest was seven

* These data have been made available through the courtesy of Miss Vickers of the Stuart Clinic which is studying the osseous development of normal children.

TABLE I

STATISTICAL ANALYSIS OF FORTY-FIVE CASES OF KÖHLER'S DISEASE

Sex Incidence:		
Females		6 cases
Males		39 cases
Age Incidence at Time of Diagnosis:		
Youngest		$2\frac{6}{12}$ years
Oldest		$7\frac{5}{12}$ years
Average		$4\frac{7}{12}$ years
Involvement:	*Females*	*Males*
Left	4	16
Right	2	14
Bilateral	0	9
Symptoms:		
Definite		36 cases
None *		9 cases
Trauma:		
Definite history		14 cases
Questionable history		2 cases
No history		29 cases

* Condition accidentally discovered in the roentgenogram.

years and five months at the time of the first examination. The average age of onset was four years and seven months. The age incidence is shown in Figure 1.

Symptoms referable to the involved area were present in thirty-six cases. In nine cases there were no symptoms and the condition was accidentally discovered in studying roentgenograms taken for other purposes.

A definite history of antecedent trauma was elicited in only fourteen cases. Twenty-nine patients gave no history of trauma. In two cases trauma was questionable.

The duration of symptoms prior to first examination was extremely varied, ranging from a few days to a year, and appeared to have no relation to the character of the roentgenographic changes. Even in cases in which symptoms had been present for only a few days, the changes shown in the roentgenograms were obviously of longer duration.

Similarly, the duration of disability had no relation to the x-ray picture, and, with complete absence of symptoms, there were marked roentgenographic changes.

In nearly half of the cases roentgenographic studies showing regeneration of the scaphoid to normal are available. The period required varied from nine months to five years, the average being two and three-fourths years. Neither the character nor the duration of the treatment was a factor in the time required for regeneration of the bone to normal.

The usual early symptoms were *pain* accompanied by a *limp* on the

TABLE II

Complete Summary of Forty-Five Cases of Köhler's Disease

Case	Sex	Age at Onset (*Years*)	Duration of Symptoms Before Treatment	Trauma	Side	Early Symptoms	Type of Treatment
1. R. B.	Male	4 3/12	4 days	No	Left	Limp, inversion.	Pads, Thomas heels.
2. U. B.	Female	2 10/12	2 months	No	Right	Limp, tenderness.	Plaster, pads.
3. C. B.	Male	5 5/12	1 year	No	Bilateral	Pain, pronation.	Pads, exercises.
4. J. C.	Male	4 5/12	1 week	No	Bilateral	Pain, tenderness, pronation.	Pads, Thomas heels.
5. C. C.	Male	6	?	No	Right	None (accidental discovery).	None.
6. J. C.	Male	3 9/12	6 weeks	No	Left	Acute pain, swelling, limp.	Caliper, pads.
7. H. D.	Male	3	9 weeks	Yes	Right	Limp, pain, pronation.	Pads, Thomas heels.
8. G. D.	Male	7 3/12	4 months	No	Bilateral	None (accidental discovery).	Plates.
9. J. D.	Male	5 1/12	6 weeks	Yes	Right	Limp, swelling, pronation.	Pads, Thomas heels.
10. E. D.	Male	4 1/12	1 week	No	Bilateral	Limp, pain, pronation.	Pads, Thomas heels.
11. E. D.	Male	6 3/12	4 weeks	Yes	Bilateral	Limp (right).	Plates, pads.
12. D. G.	Male	4 9/12	4 months	No	Left	Pain, swelling, heat.	Incision and drainage by local doctor, pads.
13. L. G.	Male	6	?	No	Bilateral	Limp, pain, tenderness.	Weight-bearing restricted.
14. H. G.	Female	4 5/12	?	No	Left	Inversion.	Pads, Thomas heels.
15. P. G.	Male	4 9/12	1 month	Yes	Left	Limp, inversion.	Plaster, strapping, pads, Thomas heels.
16. J. H.	Male	5	5 months	Yes	Left	Swelling, tenderness, limp, pronation.	Hot soaks, adhesive, pads, Thomas heels.
17. J. K.	Male	6	?	Yes	Left (?) Right	Limp, pain, swelling.	Adhesive, non-weight-bearing.
18. D. K.	Male	2 9/12	?	No	Right	Pronation, high arch (no pain).	Pads.
19. M. L.	Male	3 3/12	?	No	Right	None (accidental discovery).	None.
20. P. L.	Male	4 5/12	1 week	No	Left	Swelling, heat, tenderness.	Pads, Thomas heels.
21. E. L.	Male	3 11/12	?	No	Right	None (accidental discovery).	None.
22. J. L.	Male	4 9/12	?	No	Right	None (accidental discovery).	None.
23. M. L.	Male	4 3/12	?	No	Left	Pain.	Pads, Thomas heels.
24. P. M.	Male	4 7/12	3 days	No	Left	Limp, pain, swelling.	Plaster cast.
25. A. M.	Male	4 9/12	1 month	Yes	Right	Limp, eversion, pronation.	Pads, Thomas heels.
26. A. M.	Male	6 9/12	5 months	Yes	Bilateral	Pain, swelling, heat.	Pads, Thomas heels.
27. F. M.	Male	6 5/12	4 months	No	Left	Swelling, tenderness.	Adhesive strapping.
28. E. M.	Male	5 3/12	2 weeks	No	Right	None (accidental discovery).	None.
29. E. N.	Male	3 5/12	?	No	Right	None (accidental discovery).	None.
30. R. N.	Male	6 1/12	5 months	Yes	Right	Limp, heat, tenderness.	Plaster, pads, Thomas heels.
31. A. P.	Male	5 3/12	2 weeks	No	Left	Swelling, pronation.	Pads, Thomas heels.
32. F. R.	Female	4 9/12	1 month	No	Left	Limp, tenderness, swelling.	Plaster cast.
33. A. S.	Male	6 5/12	4 days	Yes	Bilateral	Tenderness, pronation.	Pads, Thomas heels.
34. J. S.	Male	3 1/12	7 months	No	Bilateral	Limp on left (no pain).	Adhesive strapping, pads, Thomas heels.
35. T. S.	Male	3 8/12	2 days	No	Left	None (accidental discovery).	Pads, Thomas heels, limitation of weight-bearing.
36. C. S.	Female	3 10/12	3 weeks	Yes	Left	Pronation, swelling, oedema.	Adhesive, plaster, pads, Thomas heels.
37. D. S.	Female	5 4/12	2 weeks	No	Left	Swelling, heat, tenderness.	Adhesive, pads, Thomas heels.
38. J. S.	Male	6	1 week	?	Left	Inversion, swelling, heat.	Pads, Thomas heels.
39. R. S.	Male	5 9/12		No	Left	None (accidental discovery).	None.
40. R. T.	Male	6 3/12	6 months	?	Left	Swelling, limp.	Pads, Thomas heels.
41. E. T.	Female	5 4/12	3 months	Yes	Right	Limp.	Pads, Thomas heels, plates.
42. A. V.	Male	5	3 weeks	Yes	Right	Limp, swelling, tenderness.	
43. K. W.	Male	3 5/12	3 weeks	No	Right	None (accidental discovery).	None.
44. R. W.	Male	5 8/12	5 days	No	Left	Limp, tenderness.	Adhesive, pads, Thomas heels.
45. V. W.	Male	3 4/12	4 days	Yes	Left	Limp, pain.	Plaster casts.

TABLE II (*Continued*)

COMPLETE SUMMARY OF FORTY-FIVE CASES OF KÖHLER'S DISEASE

Duration of Treatment	Duration of Disability	Roentgenographic Appearance of Scaphoid	Duration of Recovery to Normal as Indicated by the X-Ray	End Result
6 months	3 weeks	First x-rays lost.	5 years	Pronation, cavus; scaphoid regenerated to normal.
3 years	?	Flat, of increased density.	2½ years	Feet normal; scaphoid normal.
1 year	?	Flat, fragmented; 2 centers of ossification.		Normal feet; prominent dorsum, flexible, high arch.
?	3 weeks	Left: small, flat, dense. Both: several ossification centers.		
None	None	Typical.*		
4 years	1 year	Small, normal density. Later, fragmented and destroyed.	4 years	Scaphoid normal; mild pronation, feet otherwise normal.
3 months	3 months	Small, flat, dense. Later, typical.		
?	None	Irregular, fragmented, dense.		Pronation, good arch.
2¾ years	1 year	Typical.	6 5/12 years	Scaphoid normal; pronation, flat feet.
?	?	Typical.		
8 months	3 months	Two centers of ossification; irregular, dense.	1 3/12 (not quite normal)	High arch, no pronation, prominent dorsum.
	2 months	Typical.		
?	?	Typical.		
1½ years	?	Small, irregular, dense.	1½ years	Scaphoid regenerated to normal.
8 weeks	6 weeks	Typical.		
?	?	Flat, dense.	3 years	Scaphoid normal; feet normal.
?	?	Small, narrowed, normal density and outline.		
3 years	2 weeks	Small, dense, narrowed.	9 months (almost normal)	Narrow feet, no pronation; scaphoid normal; dorsum prominent and long.
None	None	Typical.		
?	1 month	Typical; no fragmentation.		
None	None	Typical.		
None	None	Typical.		
6 months	?	Typical; 2 ossification centers.		
1 month	1 month	Typical.		
4 years	1 week	Typical.	5 years	Scaphoid normal; marked pronation.
22 months	5 months	Typical.	2 years	
1 year	2 months	Typical.		
None	None	Typical.	4 3/12 years	Scaphoid regenerated to normal.
None	None	Typical.	3 years	Scaphoid normal; pronation.
2 years	10 months	Typical.	1 3/12 years	Scaphoid regenerated to normal.
		Typical; 2 centers of ossification.		
4 months	2 months	Typical.		
2 years	A few days	Typical.	2 3/12 years	Scaphoid normal; pronation, broad feet, prominent dorsum.
2½ years	6 months	Typical.	2 5/12 years	Scaphoid normal; pronation.
		Typical.	1 year	Scaphoid regenerated to normal.
1½ years	15 months	Small, irregular, mottled.		
		Typical.	9 months	Scaphoid regenerated to normal.
7 months	4 months	Typical; 2 fragments.		
None	None	Typical.		
2½ years	5 months	Typical.	2 8/12 years	Scaphoid regenerated to normal.
4 years		Typical.	3 7/12 years	Scaphoid regenerated to normal.
		Typical.		
None		Small, fragmented; 2 centers of ossification.		
?	1 month	Typical.		
?	1½ years	Typical.	3 5/12 years	Scaphoid normal; pronation, prominent dorsum.

* Typical = flat, increased density, irregular in outline.

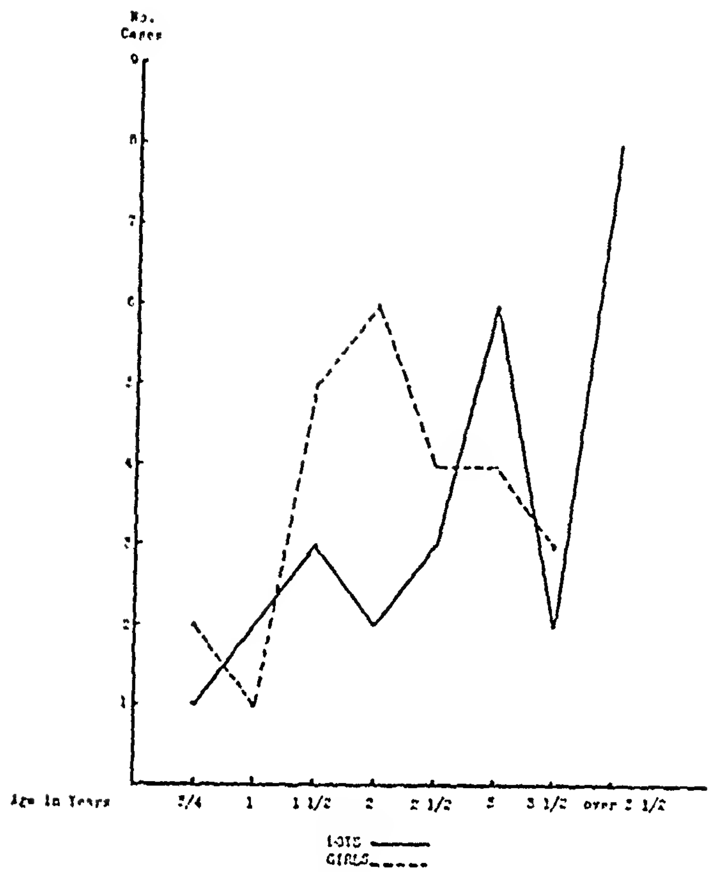


FIG. 2

Normal development of scaphoid at various age periods.

affected side, with localized tenderness and *swelling* over the dorsum of the foot. In many cases redness and local heat were present, suggesting an infectious process, and in two cases incision and drainage had been done by the attending physician prior to examination at the Children's Hospital. The foot was held in moderate *pronation* in most cases; occasionally it was found to be in the position of *inversion*.

The treatment varied according to the judgment of the attending surgeon, but the end result was the same, regardless of the type of treatment or of the absence of treatment. With restriction of weight-bearing, symptoms subsided promptly, following which activity was instituted, with a felt pad and a Thomas heel for support. Plaster casts, adhesive strapping, hot soaks, caliper splints, etc., were used at times, but such treatment did not materially influence either the course of the disease, or the duration of the disability, or the end result. Recurrence of the pain and the limp was not infrequent during the course of the treatment, but took place as frequently in the patients wearing foot supports as in the untreated patients. In one case pain recurred even after the roentgenogram showed complete regeneration of the scaphoid.

A description of the foot after complete regeneration of the scaphoid was obtained in fourteen cases. These were all normal feet, varying from a typically flat, pronated foot to a high-arched, prominent-dorsum type of foot,—all excellent weight-bearing extremities. In no instance has disability resulted, and none of the feet are "deformed".

NORMAL DEVELOPMENT OF THE TARSAL SCAPHOID

The roentgenograms of fifty normal children, taken during the age period when the scaphoid develops, were examined. There were twenty-five boys and twenty-five girls in this series. These children were all born at full term with normal deliveries. Roentgenograms

Left Right

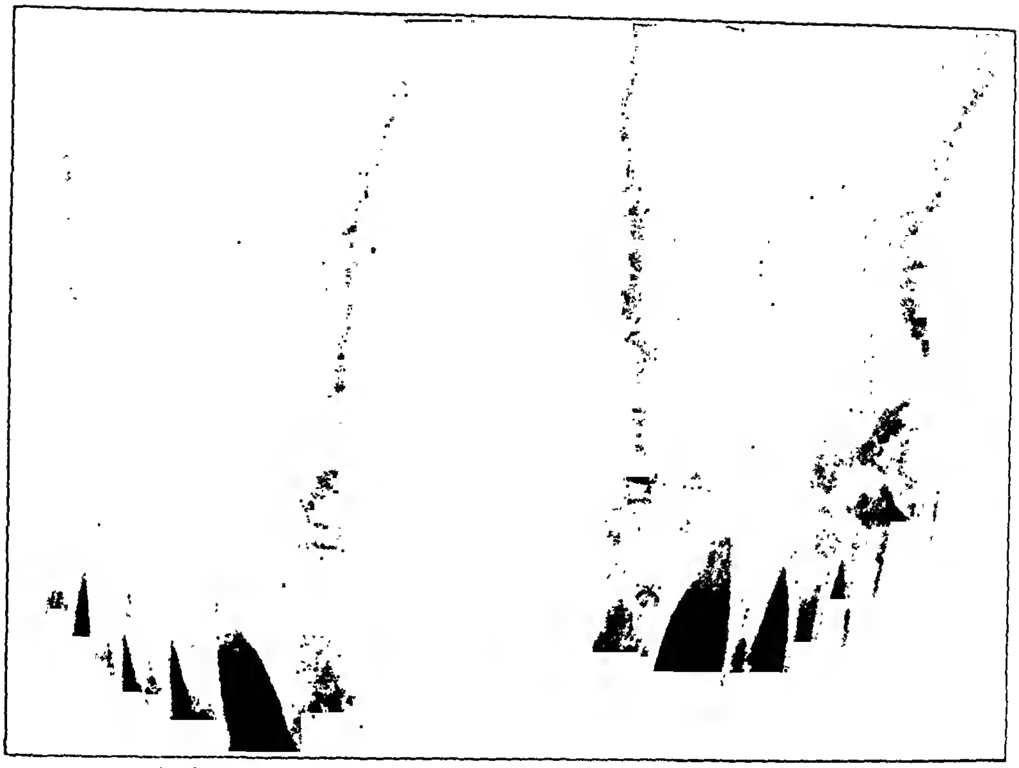
FIG. 3

Lateral roentgenograms of both feet of a boy, aged six and one-half years. The right foot shows typical Köhler's disease. The left scaphoid is slightly irregular, but normal in density. However, there were symptoms referable to both feet, and pain persisted much longer on the left side than on the right.

FIG. 4-A

FIG. 4-B

Same case as shown in Fig. 3. Roentgenograms of the right foot, taken eight months (Fig. 4-A) and eighteen months (Fig. 4-B) later than Fig. 3. Note the increased fragmentation in Fig. 4-A, followed by return to normal density in Fig. 4-B. The outline is still slightly irregular.



Right FIG. 5-A Left

July 10, 1929. Anteroposterior roentgenograms of both feet of a boy, aged three years and nine months, showing the left scaphoid to be smaller than the right, but of normal outline and density. There is marked swelling of the soft tissues and bone atrophy.

In this case there was a history of an acute onset of swelling, pain, and heat in the left foot. An incision was made; the area drained and healed quickly; and the child was walking in three weeks.

Right FIG. 5-B Left

Roentgenograms, taken September 21, 1929, showing the left scaphoid to have almost entirely disappeared, as a result of the infection, in spite of its short duration. Repeated tuberculin tests were negative.

FIG. 6-A
February 8, 1930.

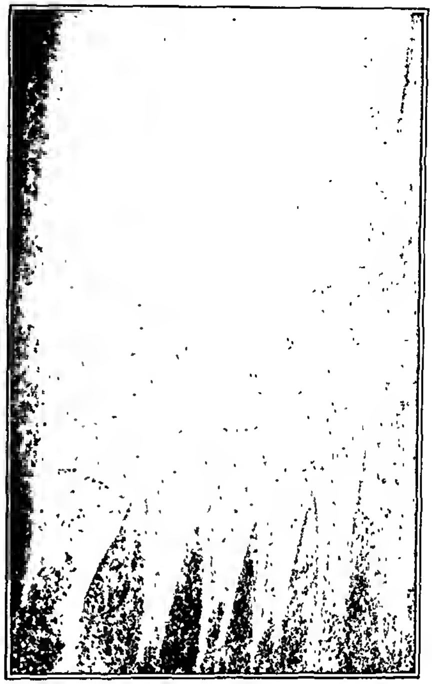


FIG. 6-B
June 7, 1930.

FIG. 6-C
February 14, 1931.

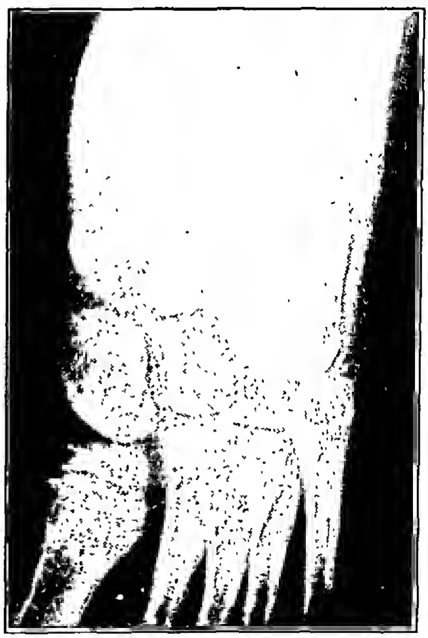


FIG. 6-D
February 3, 1932.

Same case as in Figs. 5-A and 5-B, showing the regeneration of the scaphoid in the left foot, over a period of two and one-half years following the onset. This may not be a case of Köhler's disease, although the short duration of drainage and disability is certainly atypical of a bone infection and the manner in which the scaphoid regenerated is very similar to that seen in Köhler's disease.

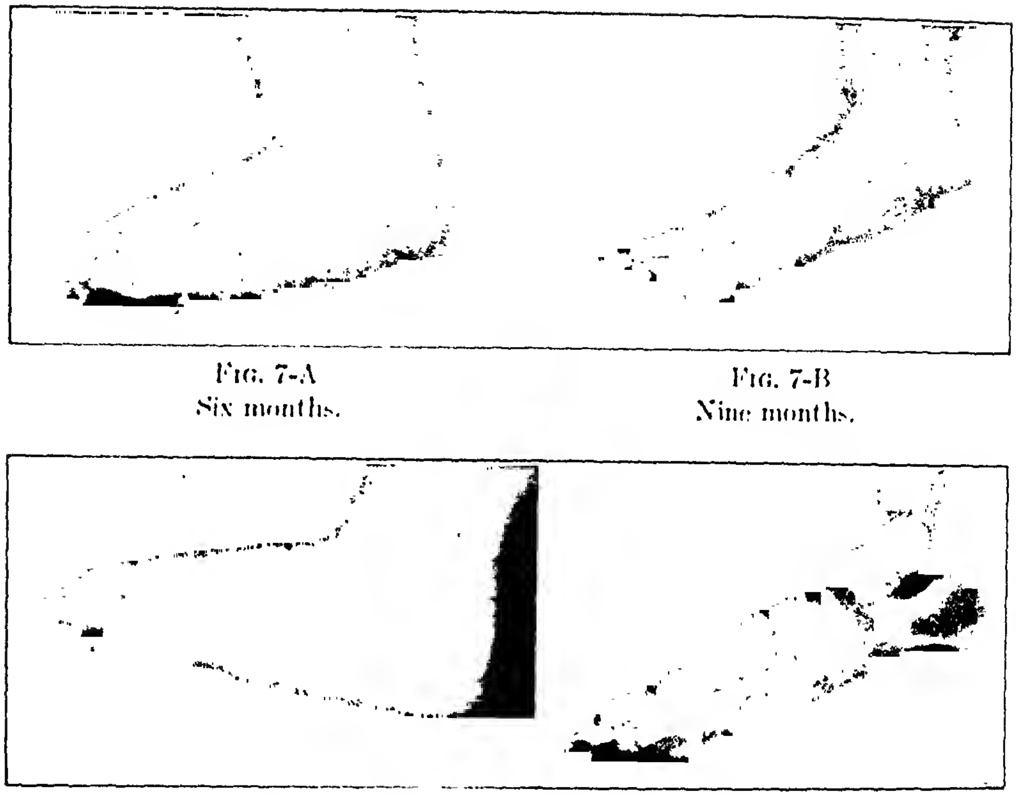


FIG. 7-A
Six months.

FIG. 7-B
Nine months.

FIG. 7-C
Twelve months.

FIG. 7-D
Eighteen months.

Lateral roentgenograms of the right foot of a girl, showing development in first eighteen months. At the age of six months, no scaphoid is visible; at nine months, a tiny osseous nucleus is present; and, at twelve and eighteen months, the scaphoid is well formed and normal in outline and density. This may be considered a case of accelerated development of the scaphoid.

were made beginning at nine months and ending at four and one-half years of age.

In this study it was possible to determine the earliest appearance of the osseous nucleus of the scaphoid, and to note its rate of development and its appearance at various ages.

Figure 2 shows that the scaphoid makes its appearance much earlier in girls than in boys. More than half the girls (fourteen cases) had a well-developed osseous nucleus at two years of age, and in all the cases the scaphoid could be seen at three and one-half years of age. Osseous nuclei were observed as early as nine months in girls.

The boys, on the other hand, were markedly retarded. It required three years for the same number of patients to show an osseous nucleus, and more than one-third of the boys were over three and one-half years old before the scaphoid appeared. Even at that age, in many of these cases, no scaphoid could be seen.

The average age for the appearance of osseous nuclei in the roentgenogram may be considered to be between eighteen months and two years in girls, and between two and one-half and three years in boys.

In following the development of the scaphoid in periodic roentgenograms, the shape, outline, and density of the bone were found to be related

Fig. 8-A
Twelve months.

Fig. 8-B
Eighteen months.

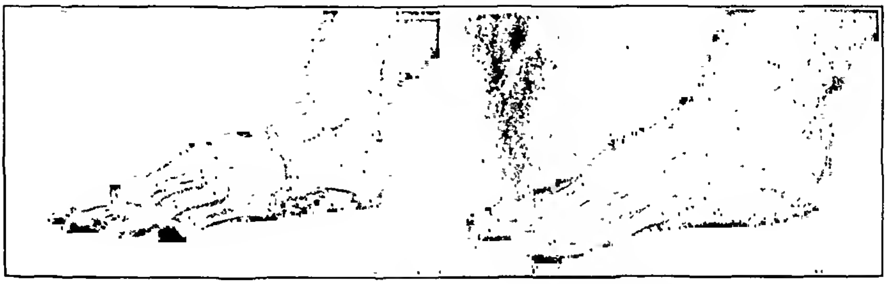


Fig. 8-C
Twenty-four months.

Fig. 8-D
Thirty months.

Roentgenograms of the right foot of a girl, taken at twelve, eighteen, twenty-four, and thirty months. In this case, the scaphoid appears at eighteen months, which is average for a girl, and in its later development is smooth in outline and of normal density.

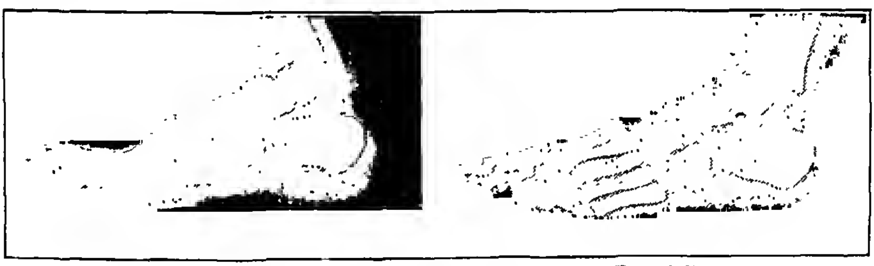


Fig. 9-A
Two and one-half years.

Fig. 9-B
Three years.

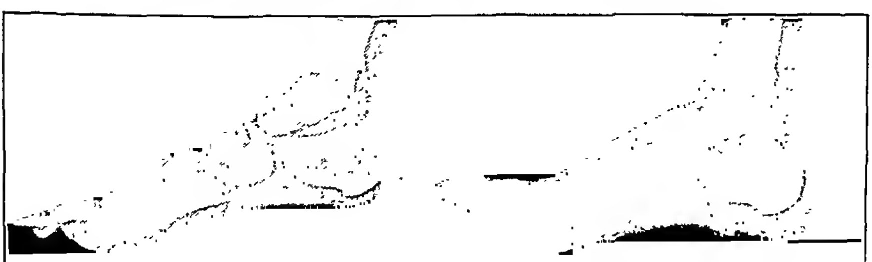


Fig. 9-C
Three and one-half years.

Fig. 9-D
Four years.

Roentgenograms of the right foot of a girl, taken at two and one-half, three, three and one-half, and four years. In this case, the scaphoid appears at three years, which is retarded for a girl, and in its later development is quite irregular in outline, somewhat fragmented, and of slightly increased density,—a picture not dissimilar to that seen in Köhler's disease.

FIG. 10-A
Six months.

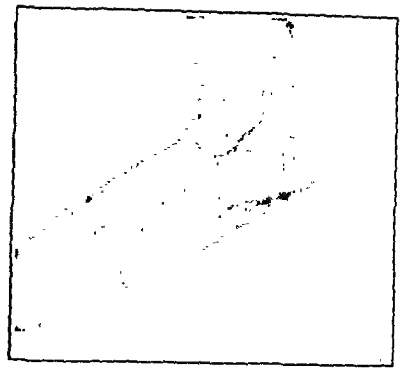


FIG. 10-B
Nine months.

FIG. 10-C
Twelve months.

FIG. 10-D
Eighteen months.

Roentgenograms of the right foot of a boy, taken at six, nine, twelve, and eighteen months. *In this case the scaphoid first appears at nine months, which is quite accelerated for a boy, and in its subsequent development preserves a smooth outline and a normal density.*

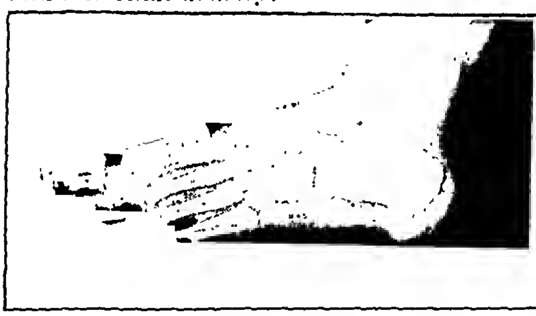


FIG. 11-A
Two years.

FIG. 11-B
Two and one-half years.

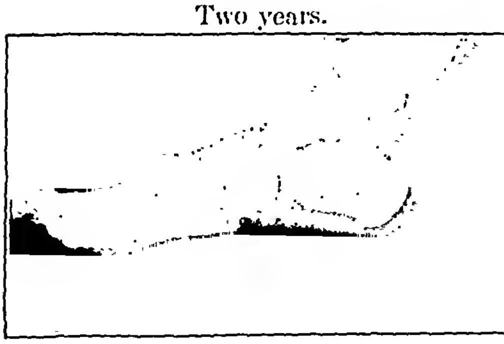


FIG. 11-C
Three years.

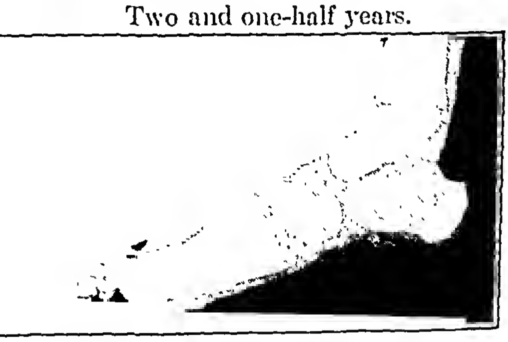


FIG. 11-D
Three and one-half years.

Roentgenograms of the right foot of a boy, taken at two, two and one-half, three, and three and one-half years. *In this case the scaphoid first appears at two and one-half years, which is average for a boy, and at three and one-half years is of normal outline and density.*

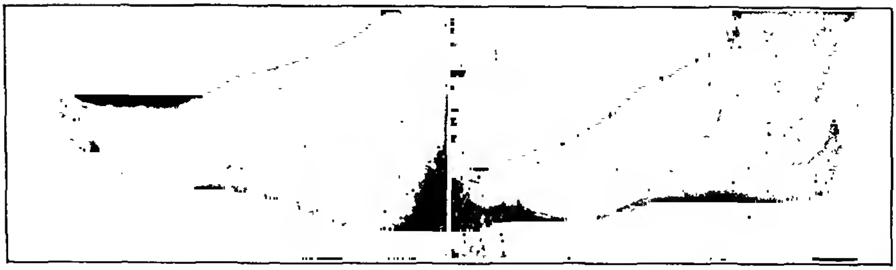


FIG. 12-A
Two and one-half years.

FIG. 12-B
Three years.

FIG. 12-C
Three and one-half years.

FIG. 12-D
Four years.

Roentgenograms of the right foot of a boy, taken at two and one-half, three, three and one-half, and four years. In this case, the scaphoid first appears at three years and, although of normal outline at three and one-half years, it becomes quite flattened, lozenge-shaped, and definitely increased in density at four years. At this age, the roentgenogram is very similar in appearance to that seen in Köhler's disease.

to the time of appearance of the osseous nucleus. The accelerated and normal-time scaphoids preserved a smooth outline, a rounded shape, and a uniform density; the retarded scaphoid, on the other hand, was very often irregular in outline, of increased density, and flattened or even fragmented in shape,—a picture often identical to that seen in Köhler's disease. Frequently several osseous nuclei appeared together and their eventual coalescence resulted in an extremely unusual configuration. This was never observed in the accelerated scaphoid and infrequently in the normal-time scaphoid. So often did this type of development occur that it would seem to be more than a chance finding. There appears to be a relationship between the time of appearance of an osseous nucleus, its configuration, and its density.

The only other tarsal bone which showed an analogous picture was the middle cuneiform, which usually appears at the same time or later than the scaphoid. No definite study of its development was made, but, when retarded in development, its configuration was often quite irregular.

It was not possible to determine the time required for these irregular nuclei to assume a normal contour inasmuch as the children studied are now only four years of age. Obviously, there was a much higher incidence of abnormal development of the scaphoid in boys than in girls, because of the retarded development of the osseous nucleus in boys as com-

pared with that of girls. When one compares this with the much higher incidence of Köhler's disease in boys than in girls, the figures take on an added significance.

A series of roentgenograms are included to show the characteristics of the accelerated, normal, and retarded scaphoids in both boys and girls.

SUMMARY

This syndrome occurs predominantly in male children between the ages of two and one-half and seven and one-half years, and is manifested by pain, a limp, swelling, and localized tenderness in the foot. It is more frequently unilateral than bilateral and has a characteristic x-ray picture which is unrelated to duration of symptoms or to treatment. Complete regeneration of the involved bone takes place in an average of two and three-fourths years, and a normal foot is the usual end result.

It is suggested by this study that the retarded development of the osseous nucleus of the scaphoid may alter its density, outline, and configuration, so as to simulate the picture of Köhler's disease.

EPIPHYSIOLYSIS OR EPIPHYSEAL COXA ANTEVERTA *

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During the past fifty or sixty years, much has been written upon the condition which is now commonly designated as epiphysiolysis, epiphyseal coxa vara, or displacement of the upper femoral epiphysis in adolescence. Practically all of the known information up to 1926 was collated in a classic article by Key. Since that time a number of other articles, dealing with special aspects of the condition, have appeared. Although the clinical picture has been delineated in considerable detail, there is still no accurate knowledge of its ultimate etiology, of its pathogenesis, or, indeed, of its treatment. In regard to this latter problem, a wide diversity of opinion exists,—radical excision or open reduction with subsequent nailing of the slipped capital epiphysis, drilling across the epiphyseal line, impaction by the Cotton mallet, and manipulation with or without the use of a brace or a plaster spica have all in turn been advocated. MacAusland, Pomeranz and Sloane, and others have attempted to come to a conclusion upon this very vital matter of therapy. It would appear from their writings that, as between the surgical and the non-surgical methods of treatment, the balance is by all means on the side of the latter.

Even in the cases conservatively treated, however, a great variation in results has been noted. Some cases gave "excellent" results and others gave "satisfactory" results, and the outcome appeared to be a matter of chance. It was because of this that the author's interest in the subject was aroused. As a matter of fact, it was the study of Case 1, in which the result was considered "satisfactory", that led to the present essay. As this case and others were studied, it was discovered that the observations made were typical of all cases of epiphysiolysis. It was then realized that the explanation of the variation in results could be attributed to an erroneous appraisal of the disease, and that the new conception, achieved as a result of the present study, would be of value in forming the basis for a better understanding and a more rational therapy of the condition. In this preliminary report an attempt will be made to present the general clinical and roentgenographic data. The more detailed study of the roentgenograms and the therapeutic consequences of the present pathogenetic concept will be reported in other communications which are now being prepared.

CASE 1. I. H., a girl, aged eleven years, was first seen on May 13, 1935. While playing ball some six days before, she had suddenly complained of pain in the right hip, which became so severe that she was confined to her bed. Because of this, the child was brought to the Hospital.

* Received for publication, May 1, 1936.

† From the Service of Harry Finkelstein, M.D.

It was observed that the length from the right anterior superior spine was twenty-nine and three-quarters inches and that from the left was thirty inches. The right leg was held in flexion and external rotation. All motions of the hip were resisted because of pain. An x-ray (Fig. 1-A), taken the following day, disclosed "complete separation of the capital epiphysis with downward and inward displacement of the epiphysis, associated with slight posterior rotation of the part".

Fig. 1-A

Case 1. May 14, 1935. Stage of fracture. The shaft is displaced upward and rotated externally. The upper end of the neck is anteverted. The capital epiphysis, of normal height, lies in the acetabulum. The larger arrow points to the tip of the greater trochanter, the smaller arrow to the upper rim of the anteverted neck of the femur.

The patient was consequently anaesthetized and the upward dislocation of the shaft was overcome. A roentgenogram (Fig. 1-B), taken on May 16, 1935, was reported as showing "overcorrection, the superior aspect of the head being one-half an inch above the level of the superior border of the neck". This was subsequently corrected, since a roentgenogram, taken through a heavy plaster spica on May 22, 1935, was reported as showing "good alignment of the capital epiphysis" and reduction of the overcorrection. The patient was discharged, wearing a large plaster-of-Paris spica.

On August 26, 1935, another roentgenogram (Fig. 1-C) was taken, which showed the epiphysiolysis previously noted. The report further

Fig. 1-B

Case 1. May 16, 1935. The varus has been overcorrected. The head is of normal height. The arrow points to the lower rim of the subcapital shadow which represents an oblique end-on view of the partly anteverted proximal end of the femoral neck.

Fig. 1-C

Case 1. August 26, 1935. This view is part of a stereoscopic roentgenogram. It explains the foreshortening of the capital epiphysis which has united to the femoral neck and has, therefore, rotated with it. The large arrow points to the lower edge of the capital shadow. The small arrow points to the edge of the subcapital shadow. Both could be seen in the roentgenogram taken in May through the plaster spica.

stated: "No alteration in the position of the capital epiphysis and neck of the femur as compared with hospital plates of May 22, 1935. Epiphyseal line almost completely obliterated." To prevent the possibility of any sudden fall, the patient was fitted with a Thomas walking hip splint.

Up to the time when this paper was written, the right hip remained free from any symptoms, although complete restoration of normal joint function had by no means been achieved. Repeated examinations revealed a definite limitation of motion in the following sense:

	Right (Affected) *Degrees*	Left (Normal) *Degrees*
Angle of flexion...... (line of the trunk being 0 degrees)	85	135
Angle of internal rotation........... (neutral position being 0 degrees)	10	35
Angle of abduction... (pelvis level, line parallel to midline being 0 degrees)	25	45

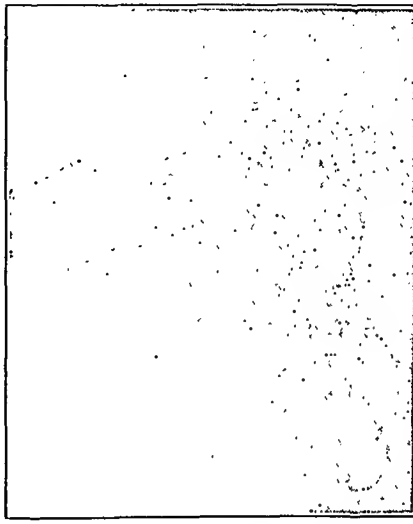

FIG. 2-A

Case 1. Lateral view, showing the anterior displacement of the head.

FIG. 2-B

Case 1. Anteroposterior view, with the leg in marked external rotation. Contrary to what is seen in the early stages of the disease, the subcapital shadow has disappeared, while the head has regained its normal height, as compared with Fig. 2-C. This paradoxical appearance is characteristic of the stage of malunion. The disappearance of the subcapital shadow can only be explained on the ground that it is cast upon the shadow of the whole length of the neck and so becomes invisible.

FIG. 2-C

Case 1. Anteroposterior view, with the leg in internal rotation of 35 degrees. Note that the subcapital shadow thrown by the femoral neck is concurrent in its lower portion with the lower part of the shadow thrown by the capital epiphysis. Because of the fact that union has taken place, the capital epiphysis has rotated and is foreshortened.

FIG. 3-A

Anteroposterior view of the hip of a normal twelve-year-old child.

Moreover, when the whole series of roentgenograms were again carefully reviewed, it was observed that, even after the so called satisfactory reduction of the slipped epiphysis, a peculiar elliptical shadow, not normally seen, was found just beneath the capital epiphysis. With the object of elucidating the significance of this shadow, a number of different x-ray exposures of the affected hip were made. Dr. Pomeranz reported on the stereoscopic plates as follows: "The width of the capital femoral epiphysis is distinctly reduced and it appears to be rotated so that its articular surface faces backward and inward. The femoral neck is anteverted, so that a considerable area of its posterior surface is in contact with the epiphyseal-plate surface of the femoral head. Therefore, the femoral neck is seen end on and facing forward. Several concentric lines are seen and their significance is appreciated only on stereoscopic vision. The outermost line represents the anterior rim of the femoral neck which has been rotated outward. The second, and somewhat indistinct line, represents the posterior lip of the epiphyseal-plate surface of the femoral head, whose shadow is projected behind the neck. The third concentric density is easily identified as the anterior rim of the epiphyseal-plate surface of the femoral head which has been rotated internally. Roentgenographically, it is evident that the coxa-vara deformity is corrected, but that the anteversion of the femoral neck persists."

As an additional check upon these findings, the hip was rotated externally 90 degrees and abducted to 90 degrees, so that a lateral view of the head and neck was obtained (Fig. 2-A). Roentgenograms were then made with the hip in 35 degrees of internal rotation (Fig. 2-C) and in 75 degrees of external rotation (Fig. 2-B) and these were compared with controls of a relatively normal hip taken in corresponding positions (Figs. 3-A, 3-B, and 3-C). All of these roentgenograms confirmed the impression that the leg had rotated externally, so that the proximal end of the femoral neck pointed forward and was not covered by the head. The head, while still in the acetabulum, was in contact with the back of the femoral neck. However, instead of lying in the axis of the neck, the head formed with the neck an angle, the apex of which in the coronal plane pointed forward and outward. Since, upon internal or external rotation of the leg, there was no change in the relationship between head and neck, it was felt that the roentgenograms represented a terminal or healing stage of the condition.*

As this series of roentgenograms and, later, other series were studied again and again, several interesting observations were made. It was seen that a very considerable degree of anterior displacement of the capital epiphysis may be demonstrated by lateral or by stereoscopic roentgeno-

* This patient subsequently developed an acute epiphysiolysis of the left hip. Since this occurred later in the chronological development of this new conception, and since the treatment instituted was a direct consequence of the idea, the further consideration of this case, especially as regards the left hip, will best be deferred until somewhat later in this communication.

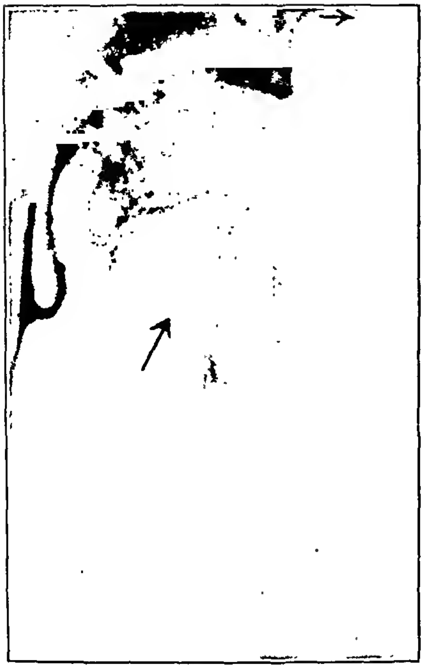

FIG. 3-B

Anteroposterior view, with the leg in external rotation. Note that the epiphyseal line can still be recognized The large shadow thrown by the capital epiphysis is indicated by the arrow. No subcapital shadow is visible. The head is of normal height.

FIG. 3-C

Anteroposterior view, with the leg in internal rotation. The epiphyseal line can be seen. The circular shadow of the head has disappeared. There is no subcapital shadow. The head is of normal height.

grams (Fig. 1-C), even though it may have been entirely unsuspected from a study of the simple flat plate. It was noted further that simple traction or manipulation for the correction of the varus deformity, due to the upward riding of the shaft of the femur in relation to the head, did not seem to insure anything more than a "satisfactory result". Even in those cases in which the varus was completely corrected, there still remained limitation of motion and roentgenographic evidence of an abnormal subcapital shadow which was not seen in any position of internal or external rotation of the normal hip. While these facts were being considered, the idea suddenly presented itself that the neglected factor, the missing link, in the rational explanation and therapy of epiphysiolysis lay in the anteversion of the neck of the femur.

The more this possibility was contemplated, the more beautifully it seemed to harmonize with the details of the clinical picture of epiphysiolysis. It emphasized the significance of external rotation in precipitating the actual slipping, and it accounted for the fact that eversion of the leg was among the earliest of the clinical symptoms. Moreover, it explained the peculiar subcapital shadow and the fact that in operated cases in which similar x-ray findings had been noted, and in which care had been taken to describe the relationship between the head and the femoral neck it had

been observed invariably that the neck pointed forward and the head was posterior to the plane of the femoral neck, or that head and neck had united so as to form an angle whose apex was forward. In order to establish this premise on a firm basis, it was felt that the early stages of the disease must be studied and that, if possible, the roentgenographic evidence of the condition should be reproduced under the control of the eye.

The former condition was fulfilled with little difficulty, since by good fortune several early cases came to hand shortly afterward. All showed in the early stages the so-called widening of the epiphyseal line which has been considered as pathognomonic of epiphysiolysis. Apart from this, the flat plate in the anteroposterior plane showed no slipping. It was only when lateral views of the head and neck were made that it was observed that even the early stages were characterized by an anteversion

Fig. 4-A

Case 2. February 4, 1936. Anteroposterior view, showing the "preslipped" stage. Note widening of the epiphyseal line.

Fig. 4-B

Case 2. Lateral view; slipping has occurred, but in the anteroposterior plane. This is the stage of moderately advanced anteversion.

Fig. 4-C

Anteroposterior view, taken a week later than Fig. 4-B, showing the characteristic upward slipping.

of the neck, which seemed to become more marked with the increase in the widening of the epiphyseal line. This is quite well shown in the following case which may be considered as typical.

CASE 2. H. H., a girl, aged ten years, was admitted to the Hospital on February 10, 1936, from the Out-Patient Department of the Good Samaritan Dispensary, where she had been under the observation of Dr. Tunick. The patient had been seen some two weeks before, when she complained of pain in the left hip, accompanied by a limp. Weight was sustained on the right leg. The left leg was externally rotated, the gluteal fold being lower than on the right side. A roentgenogram (Fig. 4-A), taken on February 4, 1936, showed the typical picture of a "widened epiphyseal line". There seemed to be good alignment of the head and neck in the coronal plane. It was only when a true lateral exposure (Fig. 4-B) was made by abducting and externally rotating the thigh that it was realized that in relation to the femoral head there was a marked forward displacement of the neck in a sagittal plane.

A week later actual upward "slipping" occurred. The trochanter rose above Nelaton's line, and there was limitation of abduction and of internal rotation. Definite shortening was noted,—the length from the right anterior superior spine was thirty and three-quarters inches, while that from the left was thirty and one-quarter inches. A roentgenogram (Fig. 4-C), taken at this time, showed a typical coxa vara on the flat plate. The condition was corrected by means of abduction and slight internal rotation, but a roentgenogram, taken through the plaster, revealed a subcapital shadow similar to that seen in Figure 1-C. Further correction of the deformity by means of marked internal rotation was recommended, but was refused. Although it is the author's opinion that this patient will display the same order of limitation of motion as was noted in the right hip in Case 1, it is still too early to determine this with accuracy.

The series of cases, of which the above is typical, served to illustrate the fact that the anteversion of the neck antedated the varus and that the correction of the one deformity in no way predicated even an amelioration of the other. They served further to call attention to the fact that anteversion of the neck seemed to be related to the peculiar subcapital shadow which was constantly seen in cases inadequately reduced. It became important, therefore, to determine the significance of this subcapital shadow—the second of the conditions previously mentioned. Ideally, the hip of an adolescent child should have been used for the purpose of experimentation, but, in spite of repeated attempts, all efforts to secure such a specimen, even from the City morgue, were in vain. In lieu of this, it was decided to use the hip of a three-year-old monkey (rhesus).* With the exception of some slight anatomical variations, the hip of this monkey may be accepted as the equivalent of the adolescent human hip.

The pelvis was first x-rayed to insure the patency of the epiphyseal line. (See Figure 5-A.) The epiphysis was then separated from the neck and replaced upon the upper posterior rim of the neck of the femur in such positions that the roentgenograms might be expected to resemble those seen in human epiphysiolysis. Some difficulty was experienced in maintaining the neck against the capital epiphysis, because of the shortness of the neck and the excessive size of the head. While the roentgenograms were not as typical as it is possible to make them, it was felt that they were

* For this privilege the author is indebted to Prof. E. T. Engle, of the Department of Anatomy at the Columbia University College of Physicians and Surgeons.

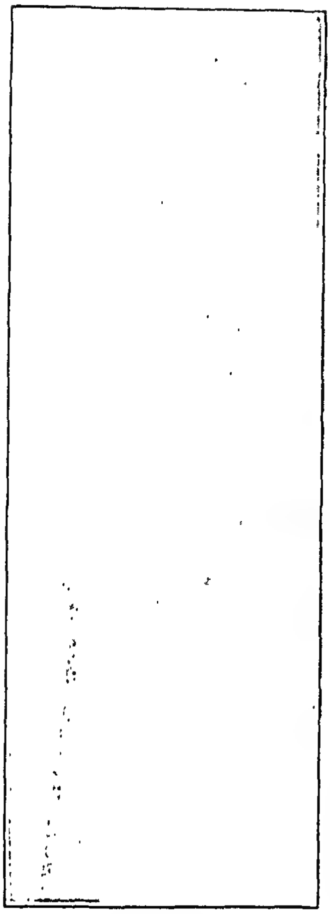

FIG. 5-A

FIG. 5-B

FIG. 5-C

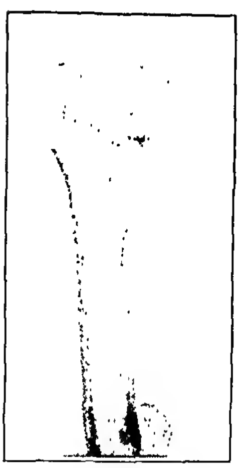

FIG. 5-D

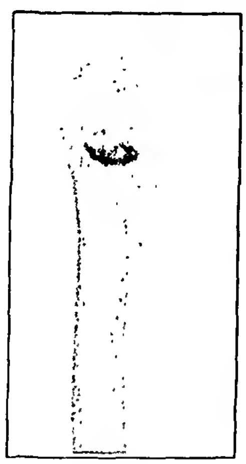

FIG. 5-E

FIG. 5-F

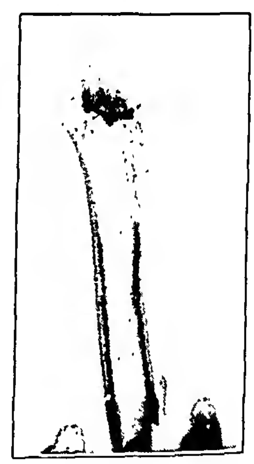

FIG. 5-G

Fig. 5-A: Normal female monkey (rhesus), three years old.

Fig. 5-B: Anteroposterior view, after separation at the epiphyseal line. The leg is externally rotated about 45 degrees. The head has been rotated backward. Note the foreshortening of the head and the subcapital shadow which is manifestly due to the upper end of the anteverted femoral neck.

Fig. 5-C: Anteroposterior view, after external rotation of the leg to 60 degrees. The steel needle has been inserted perpendicular to the center of the surface of the upper end of the neck. The head has been so placed as to show its normal height. Note that in all views the head remains in the acetabulum.

Fig. 5-D: Anteroposterior view with the leg in 45 degrees of external rotation. The subcapital shadow which is clearly seen in Fig. 5-F, when the head was removed, is obviously cast only by the upper end of the femoral neck.

Fig. 5-E: Note the increase in the subcapital shadow with increase in external rotation.

Fig. 5-F: The same view as Fig. 5-D, showing the femur with the head removed.

Fig. 5-G: The same view as Fig. 5-E, showing the femur with the head removed.

sufficiently suggestive to warrant reproduction. Figure 5-B shows the apparent decrease in the height of the capital epiphysis which was noted when the whole extremity was placed in the neutral position after the shaft of the femur had been externally rotated 45 degrees in relation to the capital epiphysis. Figure 5-C shows the increase in the height of the capital epiphysis and the "widening of the epiphyseal line", which occurred on externally rotating the shaft 60 degrees in relation to the head. During all of the manoeuvers which were undertaken, the head remained within the acetabular cavity regardless of the apparent size of the capital epiphysis. In other words, slipping of the capital epiphysis did not occur at all. The changes which were noted in the size of the head in the roentgenogram were not real but apparent, and were due to foreshortening of the head as a consequence of internal or of external rotation. The only "slipping" which did take place was a rotation,—an anteversion of the upper end of the femoral neck beneath the epiphyseal plate of the head. As this anteversion of the neck was gradually increased, so that more and still more of the upper end of the neck became visible, it was noted that the roentgenogram showed a corresponding change in the subcapital shadow. From being a small subcapital ellipse, it gradually increased in diameter until complete anteversion revealed a circular shadow, resembling fairly accurately that seen in Figure 1-C. In order to eliminate any extraneous elements, the femur was exarticulated and roentgenograms were made of its upper end as the neck was progressively anteverted. Some of these exposures (Figs. 5-D and 5-E) were made with the head *in situ* and others (Figs. 5-F and 5-G) with the head removed. As before, it was seen that, with increasing anteversion of the neck, the shadow of the epiphysis changed from an irregular line into a narrow ellipse. This gradually increased until a complete circle presented beneath the head when the neck pointed directly forward. It was apparent that these represented the shadows which were thrown by the proximal surface of the neck of the femur and which were seen first in profile and later end on.

This situation was readily comprehended as the visual expression of a fundamental proposition in projective geometry. The changing shadows represented the various projections of the roughly circular upper end of the femoral neck when exposed to the bundle of x-rays at angles varying from complete parallelism to complete perpendicularity. Once this was clearly established, it was apparent that the double shadow, observed in the roentgenograms of the monkey and of the children, was caused by the projection of two separate structures,—the upper end of the femoral neck and the lower or inferior surface of the capital epiphysis. The former cast the subcapital shadow; the latter, the capital shadow. For the purpose of calling to mind graphically the relationship which exists between the head and the neck of the femur, the acorn may be used as an example. The cup of the acorn represents the head, and that portion of the nut which fits into and is covered by the cup represents the upper end of the femoral neck. The circumference of each forms roughly a circular outline which

is in the main concurrent, and which will cast a single shadow as long as both parts are in contact. However, when this fixed relationship is modified, so that the two circumferences are no longer concurrent—when the nut rotates out of the cup—it follows that the shadows cast by each will be independent and will vary in a manner depending upon the angle at which each circumference intercepts the bundle of rays. This is exactly the situation in the condition of epiphysiolysis. As long as the head is firmly fixed to the neck, both cast a single shadow, regardless of the position of internal or of external rotation in which the leg as a whole lies. However, once a separation occurs, both the upper end of the neck and the lower end of the head cast shadows which are independent of each other and which are related to each other only by a formula expressing their angular relationship to the line of the bundle of rays. Once these facts were completely assimilated, it was realized that therein lay the explanation of the so called progressive "widening of the epiphyseal line", which has been described as pathognomonic of epiphysiolysis. It became obvious that this "widening" represented not a true, but an apparent increase in the width of the epiphyseal line. It was evident that the increase in the width of the epiphyseal line was caused by the gradual anteversion of the neck and that the roentgenographic visualization of this phenomenon was phaselike, similar to the waning and waxing of the moon. This was confirmed by the facts that anterior displacement of the femoral neck could be demonstrated only in those cases in which there was an increase in the width of the epiphyseal line and that the degree of the anterior displacement seemed to vary directly with the increasing width of the epiphysis. It further accounted for Pomeranz's observation that "the roentgenogram usually shows a widening of the epiphyseal line which is best demonstrated when the hip is examined with the leg in external rotation".

When the suggestion contained in this latter observation was carried into effect, an unexpected paradoxical situation developed. It was noted in Case 1 that, when the leg was externally rotated, as in Figure 2-B, the subcapital shadow disappeared, while on internal rotation it became very prominent. Because this was not observed characteristically in the acute cases, the paradoxical appearance was considered as typical of the late stage of the disease.* It was attributed partly to the condition produced by the superimposition of external rotation of the leg upon the anteversion of the neck, and partly to the fact that the epiphyseal surface of the neck lies not at a right angle, but oblique to the long axis of the neck. Both of these effects would be such as to modify materially the size and appearance of the subcapital shadow. However, since the detailed study of these effects is of interest only from a technical point of view and does not alter the primary argument, it is felt that the discussion may more properly be undertaken at some other time.

The matter of primary importance at this time is that both the clinical

* Figures 2-A, 2-B, and 2-C were taken rather late in the course of the disease after healing in malposition had occurred.

and the roentgenographic manifestations of the condition may be more adequately explained on the theory of anteversion of the neck of the femur than by any of the hypotheses previously advanced. Frangenheim and others have insisted that the characteristic microscopic appearance of epiphysiolysis is an actual physical widening of the epiphyseal plate, due to changes in its cartilage substance. By others, it has been contended that the epiphyseal plate is the seat of an "osteochondritis", which is the cause of the widening. Brailsford has called attention to the possibility that the condition is associated with renal rachitis, while the frequent association of that state of endocrine imbalance which is called Fröhlich's syndrome with epiphysiolysis is generally known. As concerns the latter two hypotheses, it may be stated that, while the association of these conditions is frequently noted, there is not the slightest assurance that either one is pathognomonic of the other. Epiphysiolysis may occur in the absence of renal rachitis or of Fröhlich's syndrome. On the other hand, either of these conditions may and does occur without the necessary development of epiphysiolysis. Even where both conditions are admittedly present, bilateral epiphysiolysis has been recorded in only about 15 per cent. of our series of over 100 cases. While the possibility exists that there is a definite relationship between these endocrinopathies and epiphyseal separations, it seems most likely that they act indirectly by predisposing the cervicocapital junction to the effects of trauma.

In regard to the former two hypotheses, it seems that they may be categorically denied. In this connection, it is interesting to note that a recent study by Sutro of three epiphyseal plates recovered at operation seems conclusively to dispose of the theories that the epiphyseal plate is the actual site of disease. Although the roentgenograms which he reproduced showed the characteristic widening of the epiphyseal line, his microscopic study exhibited no "definite evidence of primary degeneration of the epiphyseal plates". In his first case, he specifically stated that the capital epiphysis "had become flattened and as a result of the mushrooming had extended considerably over the neck, particularly toward the greater trochanter. On gross serial section the epiphysis was seen to bear evidence of being moderately sclerosed, especially beneath the covering cartilage of the portion which fitted into the acetabulum. Towards the greater trochanter the flattened epiphysis was somewhat atrophic." The second case showed "wavy, irregular, and reduplicated epiphyseal cartilage plates. . . . Very little endochondral ossification was present in the localized widened segments of the epiphyseal plate. Other portions of the plate, which were narrow, were undergoing closure." Case 3 similarly showed no evidence of cartilage proliferation in the epiphyseal region. His comment on these cases was as follows: "Histologic study of these specimens revealed no evidence of rickets, osteomalacia, or specific osteitis fibrosa. The pathologic condition may be interpreted as a fracture through the upper capital epiphyseal plate of the femur and through some of the contiguous osseous trabeculae."

Although Sutro's conclusion as to the nature of the condition is in all probability correct, considerable difficulty is experienced in following his explanation of the pathological principles underlying the condition. No attention is paid to the peculiar roentgenographic findings, and no mention whatsoever is made of the rotational element. The reader is left with the impression that the disease is characterized by a primary backward and downward slipping of the capital epiphysis. This, of course, is not the case. Although the factors to which Sutro calls attention undoubtedly play their part in the pathogenesis of the disease, the primary displacement is one of anteversion of the neck. The apparent slipping of the head downward, or of the shaft upward, is a secondary phenomenon. It occurs only after the anteversion has reached a maximum and the neck no longer supports the weight of the body transmitted through the head.

In this consideration, it appears that the attention of the physician should no longer be misdirected by stressing secondary effects in the denomination of the disease. Since the condition is in the nature of a fracture, it might be called a torsional or rotational fracture at the cervico-capital junction, or, better still, it might be renamed "epiphyseal coxa anteverta". While the term "epiphysiolysis" is not improper, in that it indicates a loosening of the epiphyseal plate, the terms "slipping of the capital femoral epiphysis" and "epiphyseal coxa vara" are distinctly bad because they are misleading. If the evidence here adduced is to be given credence, it must be considered as definitely established that primarily the capital epiphysis does not slip at all. During the whole process, as it was reproduced in the monkey hip, the head remained constantly in its normal relation to the acetabulum. In the acute stage, no matter whether the shaft was rotated inward or outward, or displaced upward or downward, the head remained in the acetabulum, held by the ligamentum teres and by the labrum glenoidale. At all times, it was the neck of the femur which slipped, not the head. It was only when the head became again fixed to the shaft, either by means of operative intervention or by means of healing in malposition, that the head followed the rotation of the femur. Furthermore, the primary and characteristic change in the position of the neck of the femur was not one of varus, but definitely and unequivocally one of anteversion. The varus position occurred only as a final stage in a process which had been developing and causing symptoms for weeks or months previously.

Even the term "coxa anteverta", which has been tentatively suggested, is not entirely accurate. On purely etymological grounds, the word "coxa" has no place in the description of the condition. In all propriety, the only correct term would be that which would describe an anteversion of the upper end of the femoral neck. However, since common practice has legitimatized the use of "coxa" in the sense of "neck", ample justification might be found for renaming the disease from its most characteristic finding. This term seems more capable of holding constantly before the surgeon a true picture of the pathogenesis of the condi-

tion and of its progress, and it gives a rational explanation of the clinical findings in the different stages of the disease.

In general, the progress of the condition may be divided into three main chronological stages, each of which has definite clinical and roentgenographic criteria. The first stage, called "the preslipped stage", is characterized by the onset of pain and limping, of varying intensity. Apart from a slight eversion of the foot, which is probably the earliest finding, there may be no objective signs. In this very early stage, the roentgenograms are usually reported as being negative. This, however, is the period during which the loosening or lysis at the epiphyseal plate is taking place. As the external rotation or eversion of the leg increases, the capital epiphysis follows until it reaches the limit of motion which the ligamentum teres permits. Up to this point, the head and neck are maintained in their comparatively normal relationships. Forward pointing of the foot, as in walking, permits an internal rotation of the head and neck. Beyond this point, continued eversion of the leg results in a change in the relationship between the head and the neck. Since the further rotation of the head is limited by the ligamentum teres, the continued eversion of the leg manifests itself as an anteversion of the neck of the femur at the epiphyseal line. Now, when the foot is pointed forward to permit normal progression, complete internal rotation is rendered impossible by the projection of the anteverted femoral neck. Flat or anteroposterior plates taken at this time will show the characteristic "widening of the epiphyseal line". If lateral plates are taken in addition to the simple anteroposterior views, it will be possible to demonstrate that the apparent widening of the epiphyseal line is occasioned by a gradual true anteversion of the upper or proximal end of the neck of the femur, and that the "preslipped" stage is characterized by a slipping which occurs only in an anteroposterior plane. As a consequence of the continued external rotation, a limit is reached beyond which the head finds no further support on the neck. At this extreme, a slight shortening of the leg length may be noticed. This point marks the end of the first period, which extends from the time of onset of symptoms to the time just preceding the actual upward displacement of the shaft of the femur.

The second stage is initiated by the abrupt onset of the symptoms of fracture of the neck. There is usually a history of trauma, in some cases of a specific trauma which causes an increased external rotation of the leg. In any case, there is immediate excruciating pain and inability to bear weight. The foot is usually everted, and there is shortening of the limb with elevation of the trochanter above Nelaton's line. Internal rotation, flexion, and abduction are limited. The anteroposterior roentgenogram shows characteristic upward displacement of the shaft of the femur. It will be especially noted, however, that in this phase of the affection the head is not rotated in any typical manner. It is retained in its normal position in the acetabulum and is usually of normal height. The shaft is seen to be surmounted by an elliptical shadow which varies in diameter

with the degree of external rotation of the extremity. The shaft may be rotated either internally or externally without materially or regularly affecting the position or appearance of the head in the acetabulum. This independence of the head is, of course, the consequence of the false point of motion, evidenced by the solution of continuity, the result of the fracture which occurred at the epiphyseal plate. It is the independent motion which is pathognomonic of the second phase of the disease. Its appearance marks the beginning of this phase; its disappearance marks the end of the second stage and the onset of the third or final period.

The third stage is that of fracture healed in malposition. Clinically, there are no symptoms of pain unless the condition is of long standing and is accompanied by secondary arthritic manifestations. There may be a limp, depending upon the degree of shortening, and there is definite limitation of internal rotation and abduction. The roentgenographic appearance may resemble that seen in Case 1. Stereoscopic roentgenograms and other views establish the fact that the neck is anteverted and that the head is situated upon the upper posterior edge of the neck. Roentgenograms showing internal and external rotation demonstrate that the motion of the shaft entails a corresponding motion of the head with variation in the apparent size of the capital epiphysis and of the subcapital elliptical shadow. This is the pathognomonic sign of the end stage of the affection. Thenceforth, the only changes to be noted are those consequent upon adaptations to the new set of stresses and strains which the new position of the head in its relation to the shaft of the femur determines.

From what has gone before, it appears that each phase of the disease is so essentially different that each requires a specific and different type of therapy. Treatment in the first stage (anteversion) should be dominated by preventive efforts; in the second stage (fracture), by restorative or reductive efforts; and in the third stage (malunion), by rehabilitative or reconstructive efforts. However, none of these technical attempts should be undertaken without consideration of the fact that "the more radical the surgical procedure, the worse the end results". The words are those of Pomeranz and Sloane but the opinion is, in effect, that of Key and others who have had extensive experience in the treatment of the condition.

This dictum applies with particular force to the treatment during the third stage,—the phase of malunion. When it is recalled that in this stage union has already occurred, the futility of manipulation, of drilling across the epiphyseal line, or of nailing the head to the neck will be realized. On the other hand, the justification for an extensive open operation to replace the head upon the neck, preliminary to nailing it in the new position, may well be questioned upon the basis of the end results. While it may be admitted that in some instances the results of extensive surgery, such as plastic reconstruction of the head of the femur or resection of the epiphyseal plate, have been satisfactory, it appears that as a general rule simpler measures give equally satisfactory results with far less risk. Osteotomy alone to correct alignment will do much to improve the functional outcome

and may do a great deal to prevent the late development of a secondary arthritis.

Treatment during the second stage of the disease consists essentially in the treatment of a fracture. As in dealing with other fractures, treatment must be divided into two steps: first, the reduction of the fracture and, second, the maintenance of the fragments until healing has taken place. By traction, the neck may be brought down to the level of the separated head and the shortening may be overcome. However, this alone is insufficient and the failure to correct completely the rotational deformity must be held responsible for the variable results which have been obtained. The procedure which has proved the most useful in the correction of bone deformities is the following: The patient is anaesthetized in the supine position. The operator takes a position between the legs, facing toward the patient's head. The affected limb is flexed and placed upon the operator's iliac crest. This supports the patient's limb and permits the surgeon the free use of both hands. Then, while the patient's pelvis is fixed, the surgeon grasps the limb, makes traction upon it, and at the same time forcibly rotates it internally. In the acute or even in the subacute cases, the reduction of the anteversion is manifested by a loud audible snap. The Leadbetter test usually indicates that reduction has been obtained, but neither this nor any other clinical test should be trusted as to the accuracy of the reduction. Roentgenographic examination, performed before the application of the plaster, in both the anteroposterior and the lateral positions, should be considered the only satisfactory evidence. However, since lateral views may be difficult to obtain, anteroposterior views may be used, provided that it be remembered that any roentgenogram, in which a wide epiphyseal line or an abnormal capital shadow is seen, presents positive proof of the inadequacy of the reduction.

This was shown very nicely in Case 1, in which, it will be recalled, an epiphysiolysis of the left hip developed while the patient was being treated for a similar condition in the right hip.

CASE 1. I. H. (*Continued*). In February 1936, the child began to complain of pain in the left knee. Clinical examination disclosed no evidence of any limitation of motion either in the knee or in the hip. A roentgenogram, taken on February 24, 1936, was reported as being "radiographically negative".

On April 13, 1936, the child was again brought for examination with the statement that the pain in the left hip was becoming more severe and that a slight limp was noticed. Examination revealed no limitation of motion, but the roentgenogram (Fig. 6-A), taken on April 15, 1936, was reported as showing "slight resorption of the neck of the femur adjacent to the epiphyseal line". The report further stated: "There is no slipping of the epiphysis at this time but the x-ray is suspicious of early slipping."

Five days later, the mother appeared in the Out-Patient Department and stated that the child was in severe pain and was unable to bear weight upon the left leg. An acute epiphysiolysis was diagnosed and the admission of the patient was forthwith directed. Both the clinical and the roentgenographic examinations confirmed the diagnosis. The roentgenogram (Fig. 6-B) showed a characteristic upward slipping of the shaft. The hip was exquisitely painful, and all motions were resisted. Under anaesthesia, the left leg lay in almost 90 degrees of external rotation. Flexion was possible only to 135

degrees, abduction to 45 degrees, and internal rotation to the neutral position. By means of the manoeuver previously described, reduction was effected with slight difficulty. Roentgenograms were taken in positions of internal rotation, in abduction without internal rotation, in flexion and internal rotation, and in abduction and internal rotation. The latter position seemed in this case, to give the best alignment of the head and neck. (See Figure 6-C.) The patient was consequently immobilized in a plaster-of-Paris bandage in the position of marked internal rotation (Fig. 6-D).

The excessive degree of internal rotation which was found necessary could be explained only on the following ground: As the leg was rotated internally, the posterior edge of the femoral neck impinged against the anterior rim of the head and passively rotated the head posteriorly, until its further motion was limited by tension on the ligamentum teres. It was only after this extreme of rotation had been obtained that rotation of the neck in relation to the head—that is, actual reduction of the fracture—occurred. Following reduction, the limb should be immobilized in that position which the roentgenogram shows to be optimum. In general, one may agree with Jahss that the position of flexion is better than that of extension. However, it seems that, of all the positions, it is most important to maintain the position of internal rotation. Experience shows that a combination of abduction and internal rotation with slight flexion is probably the best position for the greatest number of these cases. The following case was successfully treated in this manner as early as 1928.

CASE 3. J. H., a girl, was first seen privately in September 1928, at the age of eleven. The mother stated that the child had fallen about a year before, but there had been no

FIG. 6-A

Case 1. April 15, 1936. Note early widening of the epiphyseal line with what appears to be slight resorption of the neck adjacent to the epiphyseal line. This is the stage of anteversion.

FIG. 6-B

Case 1. April 20, 1936. Note the upward slipping of the shaft which is obviously externally rotated. This is the stage in which varus has been added to the anteversion.

symptoms until four months before examination, when a limp was discovered. This limp became more noticeable after exertion.

On clinical examination, both legs were of the same length. There was slight limitation of internal rotation. The roentgenogram showed a slight increase in the width of the epiphyseal line. The use of a hip brace was suggested to the mother, but this was refused, presumably because the author was not sufficiently stern in his insistence upon it. The patient was given general alpine exposure and cod-liver oil.

Fig. 6-C
Case 1. After reduction.

On October 20, 1928, the child was again examined, because of increasing pain. Clinically, there was increased limitation of internal rotation with limitation of abduction. No shortening could be determined. A roentgenogram was taken, which showed an increased "widening of the epiphyseal line". There seemed also to be a slight downward tilt of the head. Although at this time, the exact significance of these roentgenographic appearances was not realized, the development of what may be called a torsional fracture of the neck of the femur was taking place. However, the author again insisted upon the application of a brace, and the mother promised to give the matter consideration.

A few days later, while entering a restaurant, the patient inadvertently stubbed the inner side of her left toe against the lintel post of the door and thus sharply everted her foot and leg. She immediately fell to the floor, complaining of pain and inability to bear weight on the leg. She was taken directly to the Hospital, where a roentgenogram disclosed that the capital epiphysis had become dislocated. Under general anaesthesia, reduction was obtained with the leg in a position of wide abduction, marked internal rotation, and slight flexion. Roentgenographic examination showed satisfactory reduction, and a plaster-of-Paris spica bandage was applied and left on for a period of four months. At the end of this period, the patient wore a hip brace for ten months.

A follow-up roentgenogram, taken in October 1930, showed apparently solid union. Since that time, the patient has led a normal life, and, when examined in the latter part of 1935, showed no shortening or limitation of motion in any direction.

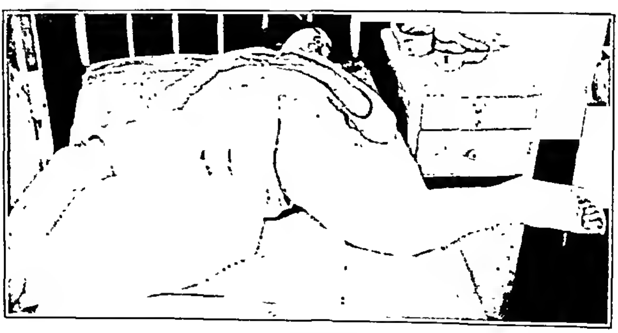

Fig. 6-D
Position of patient in the cast.

Treatment of the preslipped stage, or of what has been called here the stage of progressive anteversion, has been left for final consideration. The realization that treatment during this period

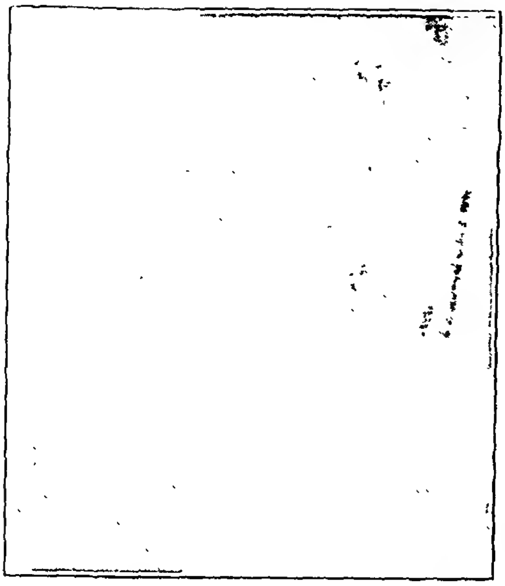

FIG. 7-A

Case 4. November 4, 1935. The "early preslipped" stage. There is only slight widening of the epiphyseal line. This is the earliest stage of anteversion.

FIG. 7-B

Case 4. March 2, 1936. Roentgenogram taken with the leg held in internal rotation by a brace. There has been a reduction in the apparent width of the epiphyseal line and a correction of the anteversion.

might spare both physician and patient the difficulties of treatment during the succeeding stage, has led to a variety of methods. With the object of preventing weight-bearing, the use of the Thomas walking caliper has been suggested. However, since the precipitating factor is, in all probability, a gradual or sudden external rotating force, it can be seen that without a device for insuring internal rotation the brace will be of no value, as many cases attest. With the purpose of obtaining premature ossification of the epiphyseal line, drilling across the epiphysis or impaction by means of the Cotton mallet has been recommended. The former method, a modification of a procedure which had been previously used in the treatment of non-united fractures and of other conditions, was employed, following a suggestion by Boszan for the treatment of Osgood-Schlatter disease. While the early results appear quite satisfactory, the method must not be considered entirely innocuous, since in one case calcification of the capsule with complete loss of all motion was the outcome of the operation. The second method, first suggested by Jahss, also appears to have given good early results. However, evidence is begin-

FIG. 7-C

Case 4. March 2, 1936. Lateral view, showing correction of the anteversion corresponding to the decrease in width of the epiphyseal line.

ning to accumulate that a mild form of arthritis may be one of the sequelae of this treatment. Thus, while each of these methods has its merits, it has also some drawbacks which justify the search for some still more harmless procedure.

Since the foregoing studies indicated that anteversion was of primary importance in the development of epiphysiolysis, it seemed natural to direct attention to that condition. It was suggested that, instead of watching with academic interest the gradual "widening of the epiphyseal line", efforts should be directed toward the cure or prevention of the disease before upward dislocation of the shaft occurred. Where the degree of anteversion was sufficient to warrant it, the patient should be anaesthetized; the anteversion should be corrected under roentgenographic control; and either a brace or a plaster-of-Paris bandage should be applied. Where the anteversion was slight, it was suggested that further progress of the condition be prevented by the application of a Thomas walking caliper, fitted to a pelvic girdle so as to maintain a marked degree of internal rotation, until closure of the epiphyseal line took place. Although the brace was intended merely to prevent the further progress of the anteversion, it succeeded beyond our best hopes, because it acted to correct the degree of anteversion which had existed prior to its application, as the following case demonstrates.

CASE 4. A. M., a boy, was first seen on November 4, 1935, some two months after he had fallen and injured his right hip. He had been examined at another orthopaedic hospital, and operation had been advised. Examination disclosed pain on all motions of the hip, with the characteristic limitation of flexion, abduction, and internal rotation. A roentgenogram (Fig. 7-A) was reported as showing "slight downward displacement of the right capital epiphysis". However, if the reproduction of this roentgenogram is carefully examined, it will be observed that, rather than a downward displacement, there is a disproportion between the long axes of the head and the neck of the femur, which gives the appearance of a downward displacement of the capital epiphysis.

When the patient was admitted to the Hospital, it was the author's intention to drill across the epiphyseal line. Because of the mildness of the condition, it was decided to observe the effect of purely conservative treatment. A walking caliper with a pelvic girdle was ordered, and, to prevent weight-bearing, a shoe with an elevated patten was prescribed for the opposite foot. (See Figure 8.) The affected foot was constantly kept in about 20 degrees of internal rotation by adjustment of the brace. Check-up roentgenograms (Figs. 7-B and 7-C), taken on March 2, 1936, showed, to the author's surprise, a decrease in the degree of anteversion. The patient did not complain of any pain or limitation of motion. When last seen, he was still free from symptoms.*

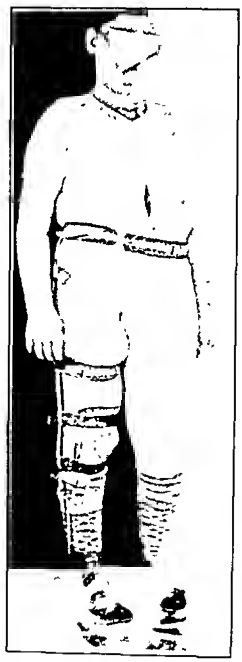

FIG. 8

The type of traction brace with pelvic girdle to insure internal rotation. Note elevated patten on opposite shoe.

* Because of the fact that closure of the epiphyseal line had not taken place, the result is herewith tendered as a preliminary note.

Since no case of epiphysiolysis can be considered as cured until the epiphyseal line has become permanently closed, it is obvious that early ossification of the epiphyseal line is urgently to be sought. In this respect, the method of drilling or of impaction has the advantage over treatment by the brace, or by the plaster-of-Paris bandage. On the other hand, attention must be called to the fact that x-ray exposure has been found to damage the epiphyseal plates. If it can be shown that such is the case and that, as a consequence, premature ossification of the epiphyseal line may be accomplished by x-ray therapy, a ready means will have been found whereby cure of the condition can be assured, once correction has been obtained. This can only be determined by further studies in this field.

SUMMARY

It is the author's opinion that so called epiphysiolysis is of the nature of a torsional fracture at the cervicocapital junction. The essential element in the production of the condition is the gradual and progressive anteversion of the neck of the femur. This is so characteristic that the disease should be renamed "coxa anteverta". The fundamental principle involved in the treatment of the disease lies in the prevention of the excess anteversion. This may be done by means of a brace with a pelvic-girdle attachment, in order to maintain internal rotation of the leg. In cases in which anteversion has proceeded to the point where the weight can no longer be supported and fracture with upward displacement of the shaft has occurred, reduction of the displacement under roentgenographic control and immobilization is recommended. The use of x-ray therapy for the purpose of premature ossification of the epiphyseal line is to be studied and reported upon at a later date.

Grateful appreciation is herewith accorded to Dr. M. M. Pomeranz, the attending roentgenologist at the Hospital for Joint Diseases, for his kindly assistance and suggestions.

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A STRAIGHT INCISION FOR ARTHRODESIS OR DRAINAGE OF THE SACRO-ILIAC JOINT

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In the past the author has usually employed the Smith-Petersen operation for arthrodesis of the sacro-iliac joint. He has felt, however, that it was a rather formidable and difficult procedure and recently he has had two patients in whom separation of the subcutaneous tissues occurred, with the result that about two weeks after the operation the skin edges separated over a small area and a considerable amount of thin, yellowish fluid mixed with fat was evacuated. The wounds continued to drain over a period of three or four weeks and they healed slowly. This experience stimulated the writer to consider the possibility of exposing the desired area on the ilium through a straight-line incision and, consequently, the following operation was devised and has been used.

OPERATIVE TECHNIQUE

The patient is placed prone upon the table with the hips slightly flexed. The skin, having had a forty-eight-hour preoperative preparation, is painted with tincture of merthiolate and the patient is so draped that the left buttock, in the region of the posterior superior spine, and the posterior part of the sacrum are exposed. The incision through the skin begins close to the midline and passes outward and slightly downward about one-half an inch below the posterior superior spine of the ilium for a distance of about six inches toward a point about one-half an inch above the greater trochanter. (See Figure 1, *1*.) This incision is slightly more transverse than the fibers of the gluteus maximus muscle and is about one and one-half inches below the superior margin of the origin of this muscle from the ilium. The outer third of the incision lies above the upper margin of the gluteus maximus, and the superficial tissues are dissected from the thin fascia over the muscle and retracted (Fig. 1, *2*). The fascia and muscle origins on both sides of the posterior part of the crest of the ilium are cut. This incision runs around the posterior superior spine, as shown by the dotted line in Figure 1, *2*, and, on the lateral aspect, part of the origin of the gluteus medius is cut. The gluteus maximus and the gluteus medius are fused near their origin, but can be separated in the lateral part of the wound. Then, by blunt dissection, the superior border of the gluteus maximus is freed up to its origin and the muscle is retracted downward. Next, the inferior margin of the gluteus medius is stripped up from the ilium and retracted upward, thus exposing the portion of the bone between the posterior part of the crest and the greater sacrosciatic notch.

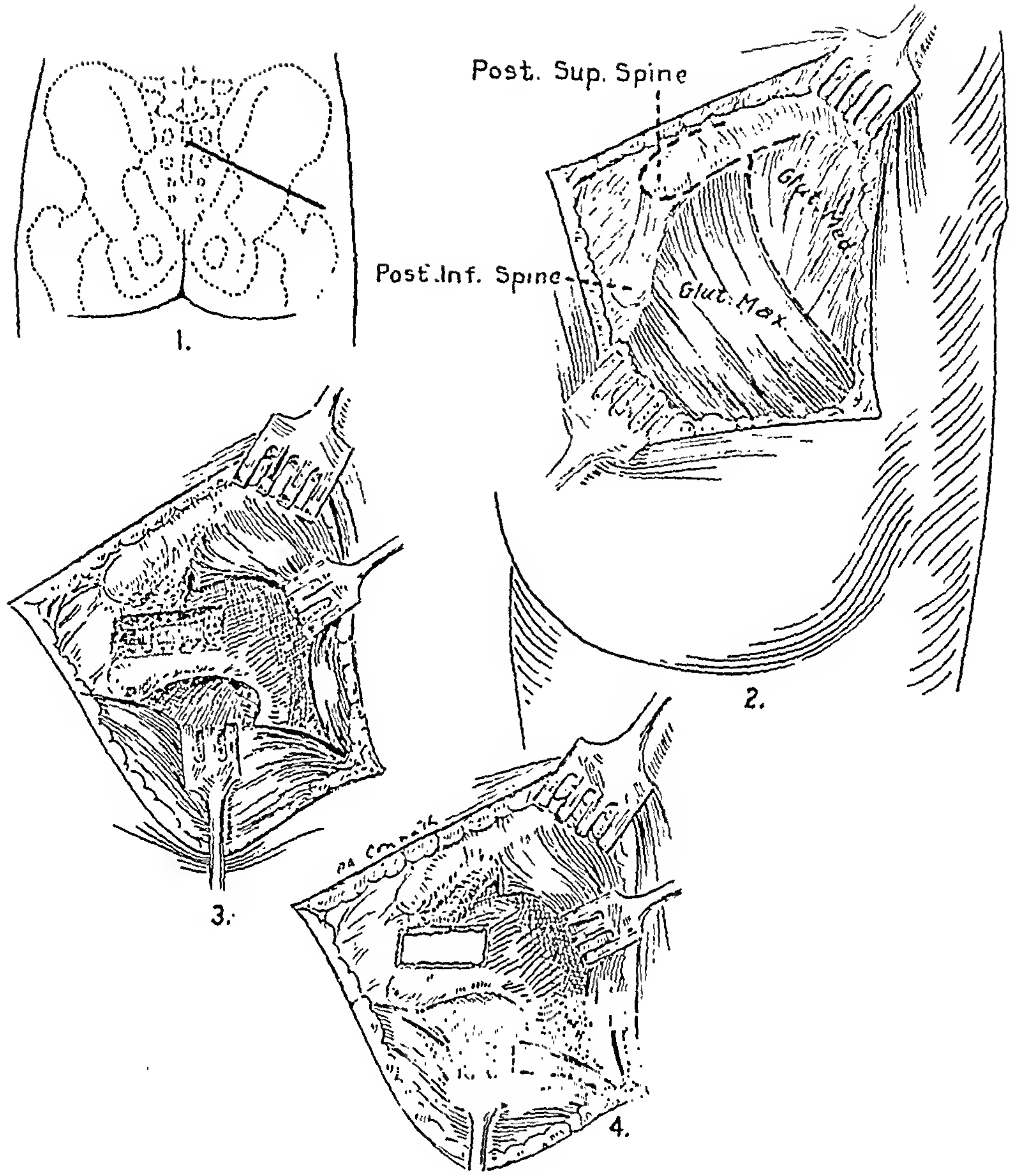

FIG. 1

Showing the steps in the operation:

1: Projection of skin incision on pelvis for arthrodesis of the right sacro-iliac joint.

2: Superficial tissues retracted to show the muscles and posterior part of the iliac crest. The fascia and muscle origins are cut from the crest, as shown by the dotted line, and the muscles are either separated or cut along the superior margin of the gluteus maximus, which is indicated by a dotted line.

3: The muscles have been separated from the ilium and retracted, and the window has been made in the ilium.

4: After the window has been extended into the sacrum, the plug is driven in and countersunk to effect an arthrodesis.

(In the illustrations, the retraction is slightly more marked than is actually obtained at the operation.)

The superior margin of this notch lies just below and parallel to the skin incision.

An alternative method is to carry the incision directly downward through the muscle to the bone just above the margin of the greater sacrosciatic notch, thus sacrificing a small part of the gluteus medius. The

periosteum and muscle origin of the posterior portion of the gluteus medius are separated from the bone and stripped upward to expose the part of the ilium above the greater sacrosciatic notch, and the periosteum along the border of the notch is stripped downward to expose this border. The tissue over the greater sacrosciatic ligament is stripped downward and that part of this ligament over the posterior margin of the sacro-iliac joint, including the posterior sacro-iliac ligaments, is removed to expose the margin of this joint.

We thus have a straight incision with the gluteus maximus below and the gluteus medius above, the incision being roughly parallel to the superior border of the greater sacrosciatic notch. By retracting the margins of the wound, exposure of the posterior portion of the ilium over the posterior part of the sacro-iliac joint is obtained. The superior gluteal vessels may or may not be seen, although they lie in the tissues deep in the lateral portion of the wound. They are not cut unless they are injured. The periosteum is stripped back around the posterior superior region of the greater sacrosciatic notch, and a window is cut from the ilium with osteotomes. It extends from the posterior border of the ilium, between the posterior superior and posterior inferior spines, directly forward and parallel to the margin of the sacrosciatic notch (Fig. 1, *3*). This window includes the full thickness of the ilium in this area and is about one-half an inch wide and an inch and a half long at the posterior part and about three-fourths of an inch wide in its anterior portion. This dowel of bone is then removed and usually contains part of the surface of the sacro-iliac joint and some tissues just posterior to this joint. In other words, the window is slightly wider than the joint at this point and is cut at a sufficient distance from the margin of the sacrosciatic notch to leave an adequate bridge of bone in that area (Fig. 1, *4*). It is approximately the window which Smith-Petersen described in his second procedure, published in 1926.

After the window has been made, the opening through the ilium is deepened into the sacrum. The exposed margin of the joint is curetted or removed with an osteotome, and small bits of cancellous bone are packed into the joint between the ilium and the sacrum. Then the deep surface of the plug is excised or roughened (the author usually cuts a number of parallel depressions across it with small, sharp rongeur forceps), and the plug is driven back into its original hole and countersunk until it extends into the sacrum about one-third of an inch. The margins of the hole in the ilium are cut off obliquely with an osteotome and the bone chips are placed over the posterior part of the sacro-iliac joint,.after a small bit of the cortex of the sacrum has been lifted with an osteotome to admit the grafts. The wound is closed by a few sutures of No. 1 chromic catgut; these sutures pull up the lower margin of the gluteus medius to the region near the posterior superior spine, and the superior part of the origin of the gluteus maximus to the crest of the ilium and posterior superior spine. Next, about three chromic sutures are put in the deep subcutaneous tissue

to relieve tension from the skin edges. The subcutaneous fat is closed with No. 000 plain catgut and the skin is closed with silk. The small vessels which are encountered during the operation are usually tied after the skin towels have been placed.

The cutting of the fascia and origin of the muscles from the posterior part of the crest of the ilium is not a part of the arthrodesis, but is done on the basis that this fascia may be a factor in causing the pain.[1]

The author has used this incision seven times in performing an arthrodesis of the sacro-iliac joint and once for drainage of this joint; in each instance the exposure has been satisfactory and the wound has healed without complications. It has also been the writer's impression that these patients have had less postoperative shock than have those on whom he has performed sacro-iliac arthrodeses by other methods.

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AUSCULTATION OF JOINTS*

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HISTORICAL SURVEY

The idea of applying auscultatory findings to the diagnosis of pathologieal ehanges in the loeomotor system is not new. Hueter, in 1885, tried to loealize joint bodies by means of his myo-dermato-osteophone, and Blodgett, in the United States, in 1902, reported stethoseopie findings of ereaking, grating, and eraeking joint sounds, most marked in ehronie arthritis.

In 1906, Ludloff, who, on auscultation of spine, sacrum, and pelvis, had observed ereaking and cracking sounds similar to those found in arthritis of the knee, went so far as to locate arthritis deformans of the eervieal spine by cireumscribed frietion noises at the atlanto-oceipital region, and saero-iliae arthritis by crepitation at the posterior iliac spines. In the knee, the first meniscus investigations by auscultation were reported by Bireher in 1913. A large number of observations were recorded by C. F. Walters in 1929. In his examination of 1600 joints, he noted the gradual increase with the years in the grating intensity. In a series of unseleeted eases the auseultatory findings showed an inerease in intensity from 1.5 per cent. in the first deeade to 81.5 per eent. in the eighth. He also emphasized the fact that the finest grating is a sign of early arthritis, when no other clinieal symptoms are present.

As far as the author has been able to determine, the first graphie presentation of joint noises was made by Erb in 1933. By using a eontact mierophone instead of air transmission, he believed that it was possible to exclude extraneous noises. Erb reeorded the results of investigation of a number of sound knees, as well as of eases of ehondromalacia of the patella, of arthritis deformans, and of meniscus lesions, and he pointed out the rather low frequency of meniscus sounds.

TECHNIQUE

For a number of years the writer systematically practised auscultation of joints, especially of knees, with the ordinary clinical stethoscope. Lately, he has supplemented this proeedure by examination with the so called cardiophone (Fig. 1). This is an instrument consisting of a diaphragm whieh is connected with a crystal; the whole is enclosed in a polished metal case with a short bell piece attached to it. A soft-rubber attachment eliminates the friction noises of the skin. This microphone is peculiarly free from microphonies (*i.e.*, handling noises), while the contaet

* Read at the Annual Meeting of the American Orthopaedic Association, Milwaukee, Wisconsin, May 21, 1936.

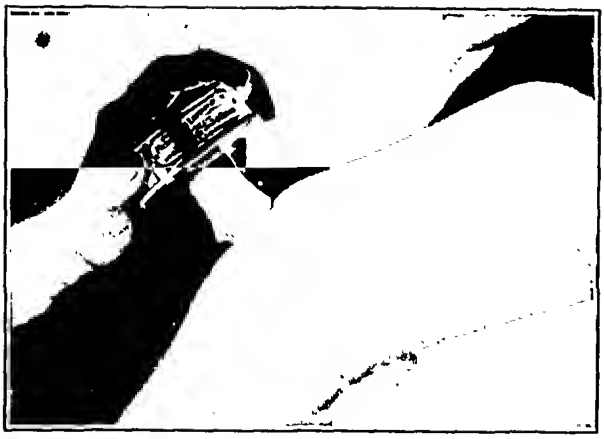

Fig. 1

The cardiophone: diaphragm with crystal in metal case, bell piece, and rubber attachment.

microphone in the writer's experience is much more sensitive to handling and friction noises. By passing the sound from the cardiophone through an amplifier to an oscillograph, oscillographic records of the sound waves are made. (See Figure 2.)

There are two great problems in the interpretation of sound phenomena: First, it is difficult to eliminate extraneous and extra-articular noises; and, second, it is not easy to locate the sound center,—that is, the exact spot from which the sound originates.

In order to exclude extraneous noises, such as friction, rubbing, and gliding of the instrument, great care is taken to apply the stethoscope or cardiophone firmly, but not too tightly, so that it will not shift during the examination.

A so called high-pass filter is used in connection with the amplifier, which cuts out all noises under 130 oscillation frequency. This disposes of the tremor noises which arise from the tremor of the hand holding the

Fig. 2

Arrangement for making an oscillographic record. Oscillograph and camera (left). Amplifier (background).

microphone. The sounds recorded in the oscillogram were in the range from 130 to 1100 oscillations, embracing about three octaves.

So far, it has not been possible to differentiate between extra-articular and intra-articular noises on the basis of the sound picture, since both occur in the same frequency limits and, especially, since they are all discontinuous in the stricter sense, even the sustained crunching and grating sounds heard in the arthritic knee. (See Figure 3.) However, with some practice, extra-articular snaps and pops, usually from jumping tendons, can be recognized by their character and location as originating outside the joint cavity.

As an aid in locating sounds, the knee is divided into four quadrants: a lower inner, medial to the patellar tendon; a lower outer, lateral to this tendon; an upper inner, medial to the quadriceps tendon; and an upper outer, lateral to the quadriceps tendon. Sometimes the auscultations are taken over the patella. In the upper outer quadrant the snapping ilio-tibial band must be avoided.

In order to distinguish between sound intensity in the different quadrants, a binaural stethoscope was devised by Mr. E. L. White, physical assistant in the Department. This instrument may be used and developed so as to be of great help in locating sounds.

In order to determine the position of the joint at which a sound is recorded, we used a goniometer, graded in intervals of 30 degrees and electrically connected with the oscillograph. Thus, by the opening and closing of contacts, the joint position is marked on a special line on the photographic paper. So far, this arrangement has served well, but better methods, which are more time-saving and less noisy, can be developed.

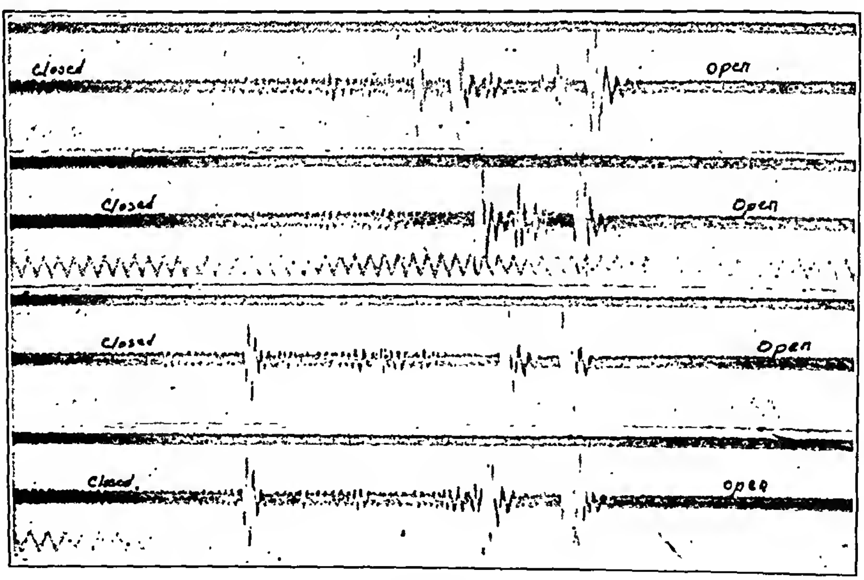

FIG. 3

Case 21. Extra-articular noise. Snapping of extensor tendon in hand.

Time is also recorded on a special line on the tape in one-hundredths of a second.

The photographic record thus shows three lines: the uppermost or position line, which gives the position of the joint in relation to the occurrence of the sound; the middle line, which records the sound itself, the height of the curve designating the intensity of the sound; and, finally, the time line at the bottom, which indicates the frequency of the sound.

CLASSIFICATION

Joint sounds were classified according to:

1. Pitch (frequency)—high or low.
2. Amplitudes of waves—loud or weak.
3. Sequence—sustained or isolated.
4. Quality (overtones, complexity of sound curve).

We used the following nomenclature:

1. Crunching (very fine, low, weak, a sustained sound).
2. Grating (coarser, higher, louder, also sustained)
   a. fine
   b. medium
   c. coarse.
3. Cracking (a harsh, sustained, high-pitched sound)
   a. fine
   b. medium
   c. coarse.
4. Isolated sounds
   a. isolated single cracks
   b. sharp pops or snaps
   c. low thuds.

Both grating and cracking are really discontinuous, although they

TABLE I

Auscultation of Normal Knees (62 Knees, or 15.61 Per Cent.)

Quadrants	Silent	Crunching	Grating and Crunching	Grating			Grating and Cracking			Isolated Sounds		Total
				Fine	Medium	Coarse	Fine	Medium	Coarse	Crack	Snap	
Lower Inner...	0	1	1	7	2	0	2	0	0	0	1	14
Lower Outer...	0	1	0	2	0	0	0	0	0	0	0	3
Upper Inner...	0	0	0	0	0	0	0	0	0	0	0	0
Upper Outer...	0	0	0	3	1	0	0	0	0	0	2	6
All..........	22	0	0	9	5	1	0	1	0	1	0	39
Total........	22	2	1	21	8	1	2	1	0	1	3	62

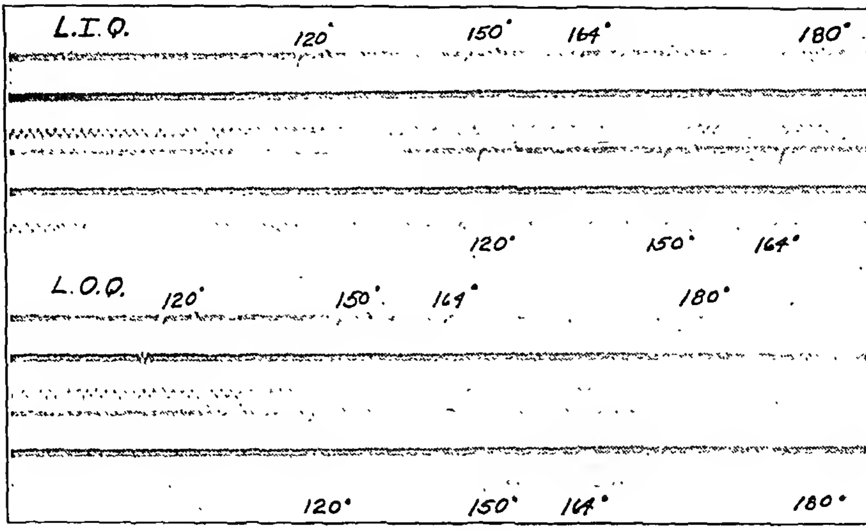

FIG. 4
Case 64. E. J. Oscillogram of the normal knee of a child, showing the lower quadrants which are silent. *L.I.Q.* = lower inner quadrant; *L.O.Q.* = lower outer quadrant.

may sound sustained. They often break up in the oscillogram into a sequence of isolated cracks.

NORMAL KNEE-JOINT SOUNDS—62 CASES

Of the 397 knees examined, sixty-two were normal. The physiological normal intrinsic sounds found in these normal knee joints were classified according to the ages of the patients.

In children under ten, the joint was almost uniformly silent in all cases. (See Figure 4.)

In adolescents and in young adults, the knee was also silent in all quadrants with the exception of very fine grating which occurred usually at the terminal positions.

In the adult past middle age, more or less continuous soft grating,

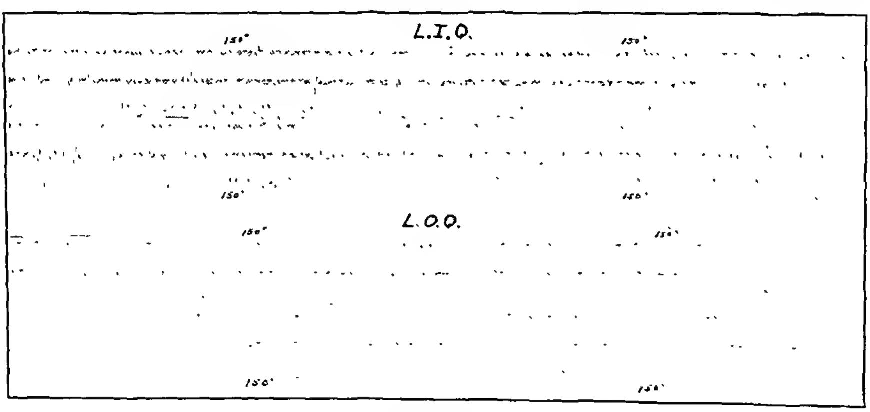

FIG. 5
Case 54. M. R. Arthritic knee. Harsh cracks in lower inner quadrant.

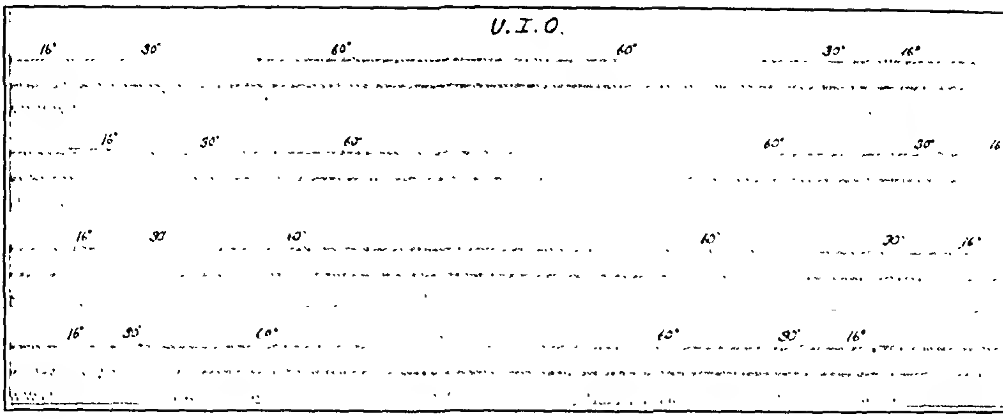

FIG. 6

Case 16. J. C. Arthritis sicca. Harsh grating in all quadrants with the knee in flexion and in extension. *U.I.Q.* = upper inner quadrant.

accentuated at the terminal positions, was common, especially in women near the menopause.

Table I shows a predominance of silent knees. In approximately one-half of the knees which were not silent, grating was present in all quadrants. Most of this grating, even in isolated cases, was of a fine nature.

The soft grating noise is occasioned principally by the intrusion of the ligamentum mucosum and the fat pads between the femoral and tibial condyles as the knee goes into full extension, and, also, by the crowding of the posterior portion of the cartilages between the joint bodies in full flexion.

PATHOLOGICAL KNEE-JOINT SOUNDS

General Joint Lesions

Arthritis—216 Cases

The sound consists of grating and cracking over full range, accentuated at the terminal positions by isolated clicks or cracks, but without very definite localization. (See Figure 5.)

TABLE II

STETHOSCOPIC FINDINGS IN ALL TYPES OF ARTHRITIS OF THE KNEE
(216 KNEES, OR 54.41 PER CENT.)

Quadrants	Silent	Crunching	Grating			Grating and Cracking			Isolated Noises			Isolated Cracks and Grating	Total
			Fine	Medium	Coarse	Fine	Medium	Coarse	Pop	Thud	Snap		
Lower Inner. .	0	0	7	4	1	0	1	2	0	0	0	0	15
Lower Outer. .	0	0	3	1	0	1	0	3	1	1	0	0	10
Upper Inner. .	0	0	2	0	0	0	0	0	0	0	1	0	3
Upper Outer. .	0	0	1	0	0	0	0	0	0	0	0	0	1
All.	19	3	71	34	22	5	6	16	3	0	4	4	187
Total.	19	3	84	39	23	6	7	21	4	1	5	4	216

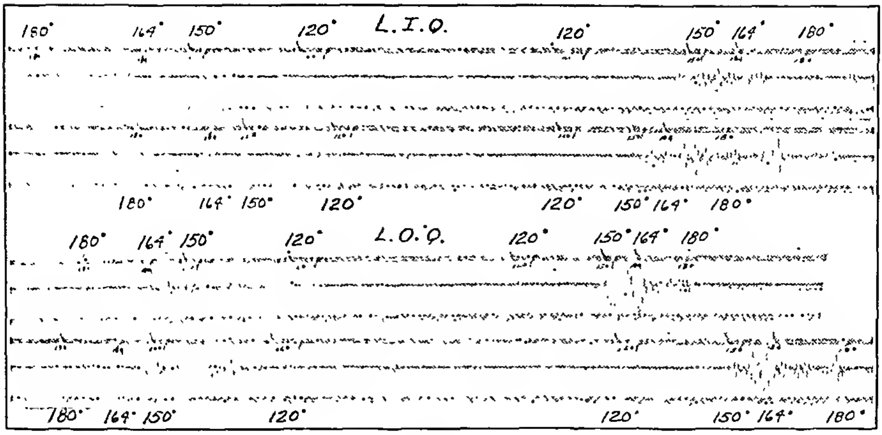

FIG. 7

Case 30. E. R. Post-traumatic arthritis. The semilunar cartilage has been removed. Lockage and swelling are still present. The harsh grating and isolated clicks indicate arthritic changes plus definite mechanical impediment. Good correlation.

Table II shows a predominance of knees in which fine and medium grating sounds were present in all quadrants. There was a definite absence of isolated sounds in the separate quadrants.

Sharp grating in all quadrants in most of the ranges was particularly noted in a case of degenerative atrophic arthritis (Fig. 6).

CASE 16. J. C. Operation revealed hypertrophied villi, pannus formation, thickened synovia, fibrous adhesions in the suprapatellar pouch, and chondromalacia of the patella. The distribution of grating denoted a general involvement of the joint; there was no localization. There was good correlation between the stethoscopic, cardiophonic, and oscillographic records.

CASE 30. E. R. This patient had post-traumatic arthritis. Although the left semilunar cartilage had been removed, relocking and swelling were still present. The auditory findings were harsh grating in all quadrants, indicating the generalized arthritic changes, and a definite click in the lower outer quadrant, indicating some mechanical impediment. (See Figure 7.) There was good correlation between the stethoscopic, cardiophonic, and oscillographic findings.

Villous arthritis was present in twelve cases. In this type there is continuous soft grating in all quadrants. The grating becomes harsher with increasing induration of the villi. The history of repeated traumatic locking indicates more severe traumatization of the villi.

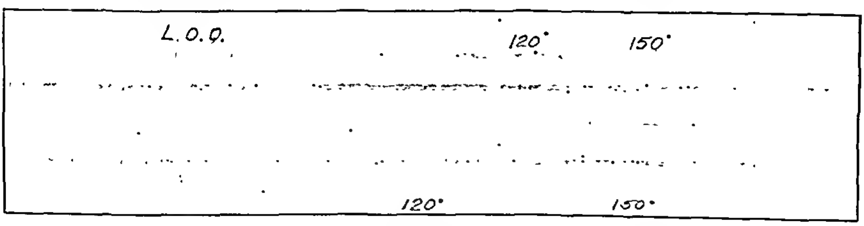

FIG. 8

Case 69. J. F. Villous arthritis. Soft grating. Good correlation. Operation showed hypertrophied fat pads.

TABLE III

Cases of Osteochondritis Dissecans (23 Knees, or 5.79 Per Cent.)

Quadrants	Silent	Crunching	Grating			Grating and Popping			Isolated Sounds			Isolated Thud and Grating	Isolated Crack and Grating	Total
			Fine	Medium	Coarse	Fine	Medium	Coarse	Pop	Thud	Snap			
Lower Inner	0	0	1	0	0	1	0	0	0	0	0	0	1	3
Lower Outer	0	0	0	0	0	0	0	1	0	1	0	1	0	3
Upper Inner	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Outer	0	0	0	0	0	0	0	0	1	0	0	0	0	1
All	2	1	5	1	0	1	0	0	0	0	3	0	3	16
Total	2	1	6	1	0	2	0	1	1	1	3	1	4	23

Case 69. J. F. This patient was fifty-five years old and had villous arthritis. Preoperative auditory findings revealed continuous soft grating in full range in all quadrants. (See Figure 8.) There was good correlation between the stethoscopic, cardiophonic, and oscillographic findings. The operation showed hypertrophic arthritis with large hypertrophied fat pads.

Osteochondromatosis—3 Cases

Of the three cases of osteochondromatosis, one displayed fine grating in all quadrants, while the other two gave evidence of coarse grating and cracking.

As one would expect, the auditory signs are marked by multiple,

TABLE IV

Derangement of the Internal Semilunar Cartilages (57 Knees, or 14.36 Per Cent.)

Quadrants	Silent	Crunching	Grating and Crunching	Grating			Grating and Cracking			Isolated Sounds			Thud and Cracking or Grating	Total
				Fine	Medium	Coarse	Fine	Medium	Coarse	Thud	Crack	Snap		
Lower Inner	0	2	0	7	0	1	1	0	1	2	0	2	0	16
Lower Outer	0	0	0	1	0	0	0	1	1	1	1	2	0	7
Upper Inner	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Upper Outer	0	0	0	1	0	0	0	0	0	0	0	1	0	2
All	4	0	0	8	3	2	0	1	2	0	1	9	1	31
Total	4	2	0	17	3	3	1	2	4	3	2	14	2	57

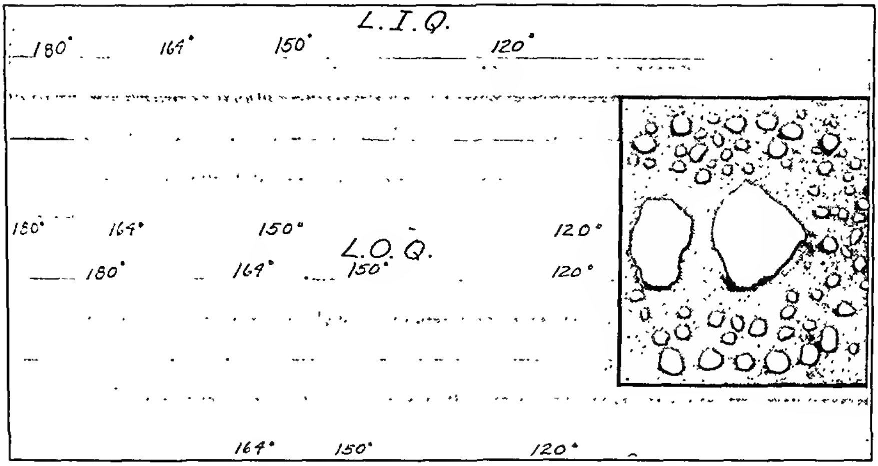

FIG. 9

Case 58. A. G. Osteochondromatosis of the left knee. Isolated sharp cracks in the lower quadrants. Good correlation.

sharp, isolated cracks in one or more quadrants, very inconstant as to location, upon a background of general more or less sharp, high-pitched grating. The intensity of the sounds, as well as the pitch, is greatly influenced by the degree of effusion.

CASE 58. A. G. In this case examination revealed osteochondromatosis of the left knee. Isolated sharp cracks were audible in the lower quadrants, as well as in the upper inner quadrant, with continuous sharp grating. (See Figure 9.) There was good correlation between the stethoscopic, cardiophonic, and oscillographic findings. The operation showed scarred fat pads, degenerative changes at the medial femoral condyle, and numerous small bodies.

The diagnosis, of course, was made on the usual physical and roentgenographic examinations, but the auditory findings indicated the general arthritic reaction of the joint.

Localized Joint Lesions

Osteochondritis Dissecans—23 Cases

If there is an arthritic background, the general joint sounds which have been described are heard without particular localization. The auscultatory findings of the free body or bodies depend on the location. If the free body is situated in the anterior compartment, a loud click is heard near full extension.

Table III shows the absence of isolated sounds. In this group there were six knees in which isolated sounds were heard in all quadrants. The fine grating was associated with the knees which showed the most arthritic changes.

CASE 23. G. R., fifty-nine years of age. The stethoscope and cardiophone revealed medium sharp grating in all quadrants, with the knee near full extension. The grating was at its maximum in the lower outer quadrant. In addition, there was a loud click in the lower inner quadrant, with the knee near full extension.

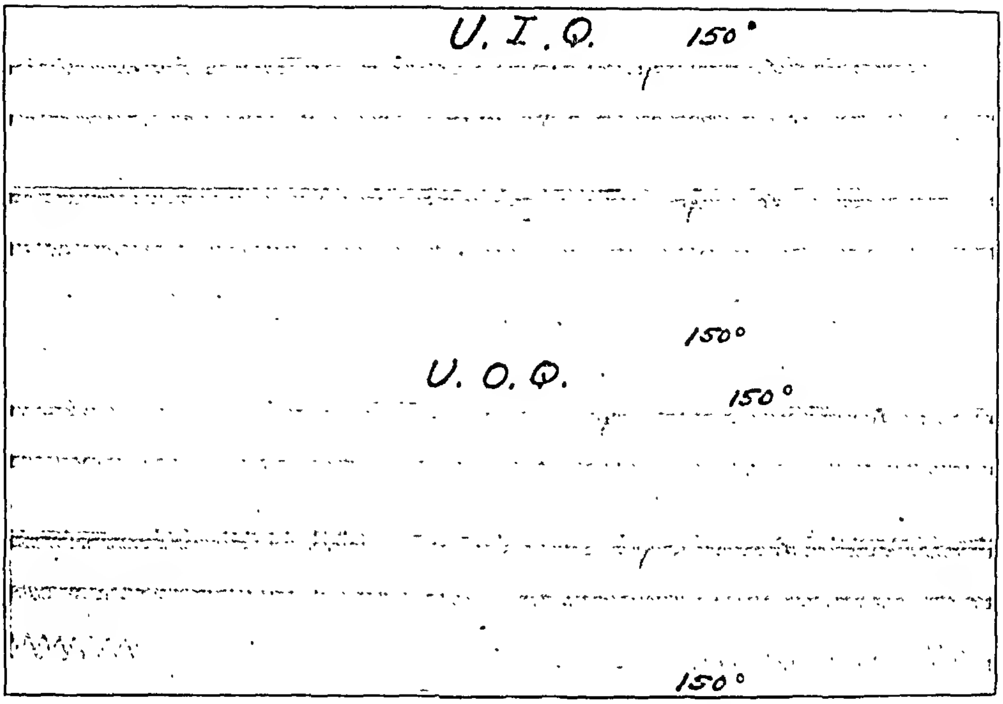

FIG. 10

Case 23. G. R. Osteochondritis dissecans. Postoperative oscillogram, showing some slight universal grating. The sharp grating and isolated clicks have disappeared.

A parapatellar incision was made, and the joint showed hypertrophied fat pads and a free body in the lower inner quadrant. Following the operation, the universal grating remained, but the click had disappeared. (See Figure 10.)

In another case of osteochondritis dissecans (G. K.), the stethoscope revealed in the upper outer quadrant a sharp, loud, cutting sound at the outer margin of the patella. When the knee was opened by a median parapatellar incision, a free body was found in the lateral compartment. The defect in the median femoral condyle was scarred over. There was also a chondromalacia of the patella, but this condition produced no sound.

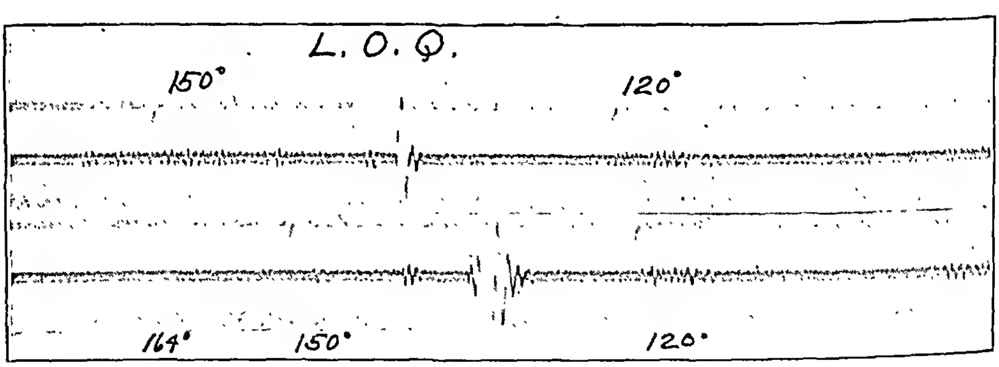

FIG. 11

Case 71. J. V. Injury to the internal semilunar cartilage of the left knee. No operation was performed. The stethoscope and cardiophone revealed a dull thud in the lower inner quadrant and a click in the lower outer quadrant. The oscillogram carries the click only.

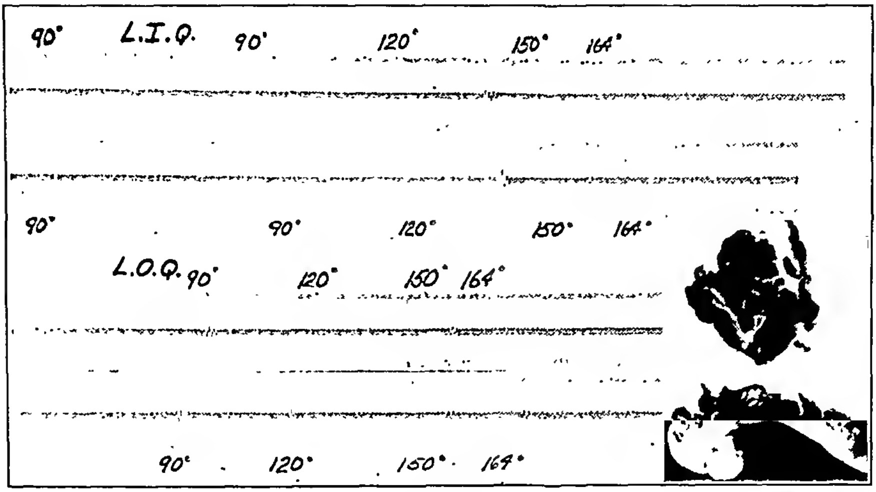

Fig. 12

Case 67. M. M. Injury to the internal semilunar cartilage of the right knee. In this case an operation was performed. The lateral meniscus of the other knee had been removed previously. The stethoscope and cardiophone recorded a dull thud at 140 degrees. The oscillogram shows a distinct thud at the same point. At operation a fracture of the internal semilunar cartilage was revealed.

Injuries to the Semilunar Cartilages—57 Cases

These cases were especially interesting, as auditory findings gave information in regard to locking, which was not obtained from the history or from the elinieal examination. Both eharacter and loeation of sound were of importanee. On quite a number of occasions a dull thud was heard in the lower inner quadrant, either on eompletion of extension or on completion of flexion, and we believe that this is suggestive of eartilage injury. When the internal meniseus was involved, the location of sound origin was regularly the lower inner quadrant, and in a number of doubtful cases the approach to the joint was thereby indieated and corroborated by operative findings.

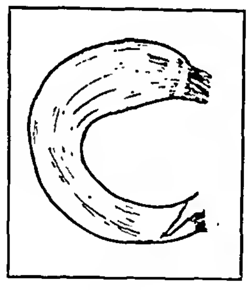

Fig. 13

G. C. Injury to the internal semilunar cartilage of the left knee. The stethoscope revealed a sharp click with the knee in complete extension, with the feeling of replacement in the lower quadrants. The click was not constant. At operation, through a parapatellar incision, a fracture of the internal semilunar cartilage with inside displacement of the flap (floating) was found.

Table IV shows that there was a tendency for the isolation of sounds in definite quadrants. In sixteen knees the sounds were localized in the lower inner quadrant and in seven knees in the lower outer quadrant. Those knees in which there was grating in all quadrants probably had associated arthritic changes.

The following case is illustrative of the findings in non-operated cases.

Case 71. J. V. In this case of injury to the internal semilunar cartilage, the pressure point was the lower inner quadrant. The stethoscope and cardiophone revealed a dull

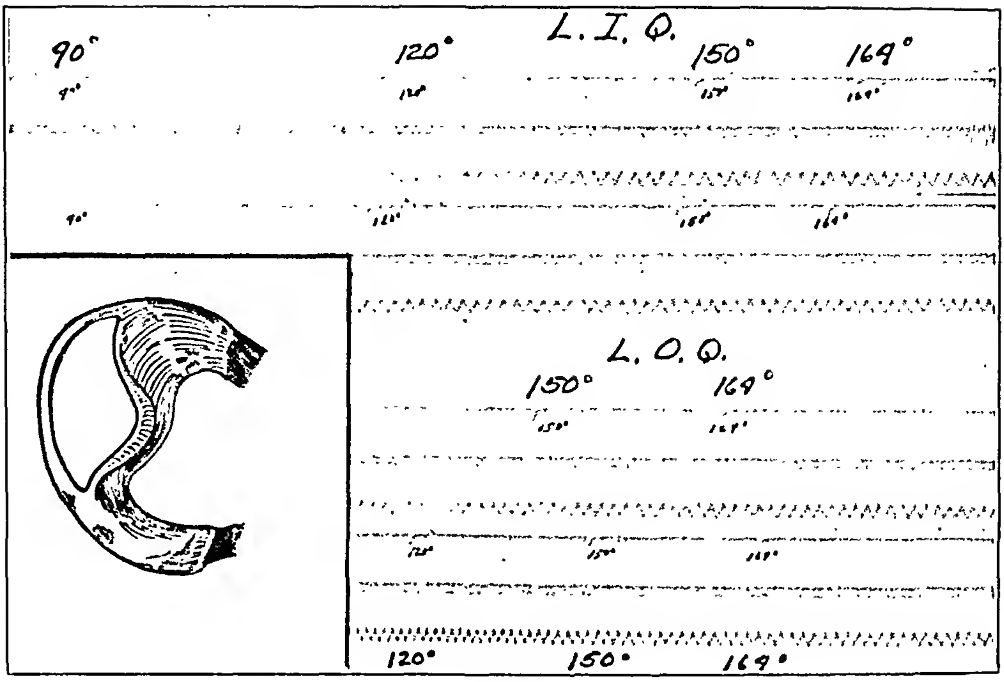

FIG. 14

Case 18. R. G. Postoperative. Injury to the external semilunar cartilage of the right knee. The stethoscope disclosed a sharp click in the lower outer quadrant with the knee in extension; the cardiophone gave the same result. At operation, through the Jones incision, a bucket-handle fracture of the external semilunar cartilage was revealed. Postoperative stethoscopic, cardiophonic, and oscillographic examinations showed that the click had disappeared. Good correlation.

thud at the lower inner quadrant upon completion of extension and a sharp click at the lower outer quadrant. This oscillogram carried the click, but not the thud, possibly because the knee was not fully extended. (See Figure 11.) These findings indicated some lesion of the anterior portion of the internal semilunar cartilage.

The same dull thud was heard in other cases in the lower inner quadrant, with the knee in extension, correlating the stethoscopic and the oscillographic findings, and was also interpreted as due to internal semilunar injury. Clinical findings were locking and pain.

After these experiences it was of particular interest to check up the auditory findings in operated cases.

CASE 67. M. M., seventeen years of age, sustained an internal derangement of the right knee. Sudden locking occurred, and there was pain on the medial side. This patient had been operated upon before for a bucket-handle fracture of the lateral meniscus of the opposite knee. Both stethoscope and cardiophone recorded a dull thud at the lower inner quadrant between 80 and 180 degrees, indicating that the sound was more probably localized in the posterior compartments. Operation on the right knee showed a longitudinal fracture of the internal cartilage. (See Figure 12.)

CASE 3. P. D., thirty-six years of age, experienced frequent locking and pain on the lateral aspect of the left knee. The stethoscope recorded a dull thud in the lower inner and outer quadrants between 60 and 90 degrees. The cardiophonic findings tallied with the stethoscopic. The diagnosis was tear, probably of the internal cartilage, but, because of the ambiguity of the localization, a parapatellar incision was made. This showed a transverse tear of the internal semilunar cartilage, with the fragment curled up, which probably accounted for the thud. A pop, heard once at earlier examination, probably meant temporary engagement of the lateral free end. The preoperative diagnosis,

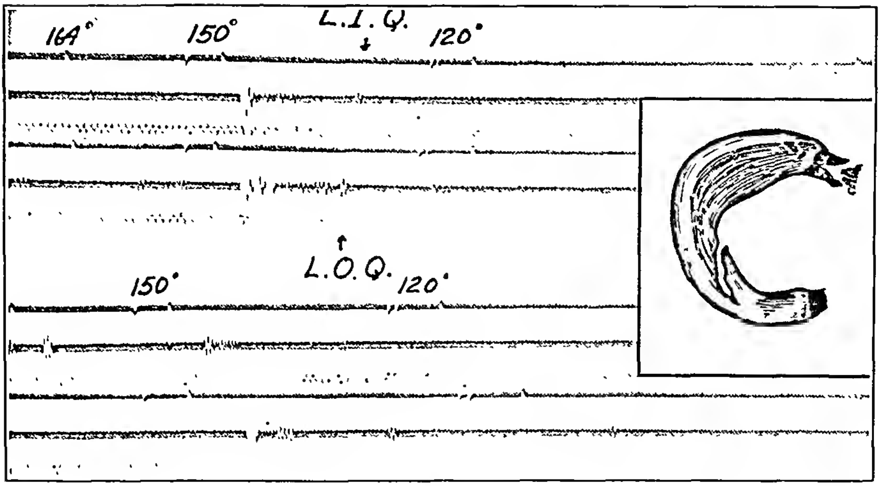

FIG. 15

Case 41. O. K. Preoperative. Injury to the internal semilunar cartilage of the left knee. Stethoscopic and cardiophonic examinations revealed a dull thud in the lower inner quadrant, with the knee near complete extension; in the lower outer quadrant, the thud was less audible. Oscillographic examination gave the same result. At operation, through the Jones incision, a double fracture of the semilunar cartilage was found. Absolute correlation.

made on the history, clinical examination, and auditory findings, was confirmed by operation.

Sharp clicks seem to denote injury to the semilunar cartilage, if they occur at terminal points, and they are often associated with a feeling of displacement.

CASE G. C., thirty-two years of age. This patient sustained an internal derangement of the left knee. There was a history of catching, lockage, and inability to extend the knee. These attacks had been numerous. Tenderness was present over the internal semilunar cartilage. The stethoscope revealed in the lower inner and the lower outer quadrants a sharp click with the knee in complete extension, associated with a feeling of replacement. (See Figure 13.) A parapatellar incision was made, but we believe that the internal Jones incision would have been justified on the basis of the physical and auditory findings. Operation revealed rupture of the internal semilunar cartilage near the anterior end with inside displacement of the flap. The click heard before operation was not constant, which indicated a detachable body,—a free body or a ruptured semilunar cartilage with a movable fragment. Operation confirmed the diagnosis.

CASE 18. R. G. In this case there was a fracture of the external semilunar cartilage of the right knee. The stethoscope revealed a sharp click in the lower outer quadrant, with the knee in complete extension. The cardiophone recorded the same click in the same location. Therefore, a Jones incision was made over the external cartilage, and a bucket-handle fracture was found.

After operation, both stethoscopic and cardiophonic examinations revealed that the click had disappeared from the lower outer quadrant, and the oscillogram showed only moderate roughness. (See Figure 14.) This is a case in which the diagnosis absolutely confirmed the auditory findings.

CASE 41. O. K. This patient sustained anterior and posterior longitudinal fractures of the internal semilunar cartilage of the left knee. The stethoscope and the

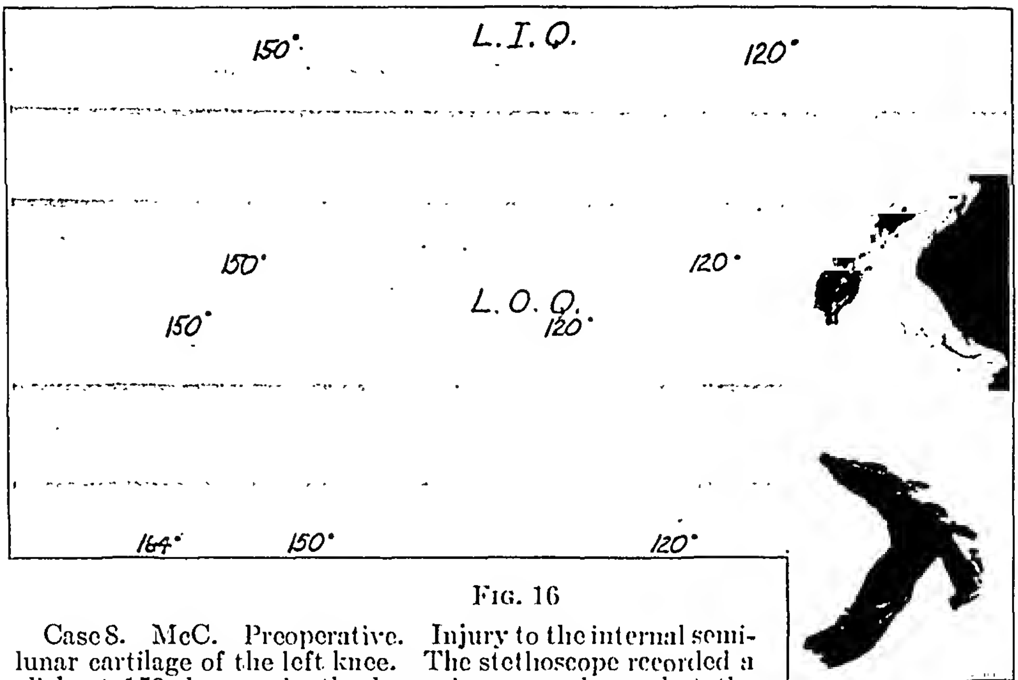

FIG. 16

Case 8. McC. Preoperative. Injury to the internal semilunar cartilage of the left knee. The stethoscope recorded a click at 150 degrees in the lower inner quadrant, but the cardiophone and oscillograph were silent. Operation revealed detachment of the anterior half of the internal semilunar cartilage, which slipped without an audible click. Good correlation. The stethoscopic findings were the most reliable.

cardiophone revealed a dull thud with the knee in or near complete extension. (See Figure 15.) This coincided with the clinical findings and, accordingly, a Jones incision was made over the lower inner quadrant of the left knee. A double fracture of the internal semilunar cartilage was found,—the first extending along the medial border and the second being a fish-tail fracture of the anterolateral attachment. There was also an erosion of the anterior portion of the femoral cartilage, which was trimmed off. This case absolutely coincided with the diagnosis made, both clinically and by auditory findings.

In the following cases, no thuds or clicks were present.

CASE 8. McC., thirty-five years of age, was found to have suffered an internal derangement of the left knee, with repeated lockage and catching. The stethoscope clicked at 150 degrees in the lower inner quadrant, but both the cardiophone and the oscillogram were silent except for slight crunching in the lower inner quadrant. (See Figure 16.) Operation showed loose detachment of the anterior half of the internal semilunar cartilage, which seemed to slip in and out without clicking. The click was occasional only, and the operative findings were in harmony with the auditory findings.

CASE 72. J. G., thirty-nine years old, sustained a bucket-handle fracture of the internal meniscus of the right knee. There was a history of repeated locking. The stethoscope was silent, except for fine grating in the lower inner quadrant at terminal positions. The cardiophone seemed to give a dull thud in the lower inner quadrant, with the knee in flexion and in extension, and the oscillogram also showed dull thuds between 120 and 150 degrees in the lower inner and lower outer quadrants. (See Figure 17.) The joint was opened by an internal Jones incision, and a bucket-handle fracture of the internal cartilage was found. The physical examination pointed to the inner cartilage, but the auditory findings were somewhat uncertain.

If we examine the fourteen cases in which operations were performed with resultant cure, we find good correlation of auditory findings. These

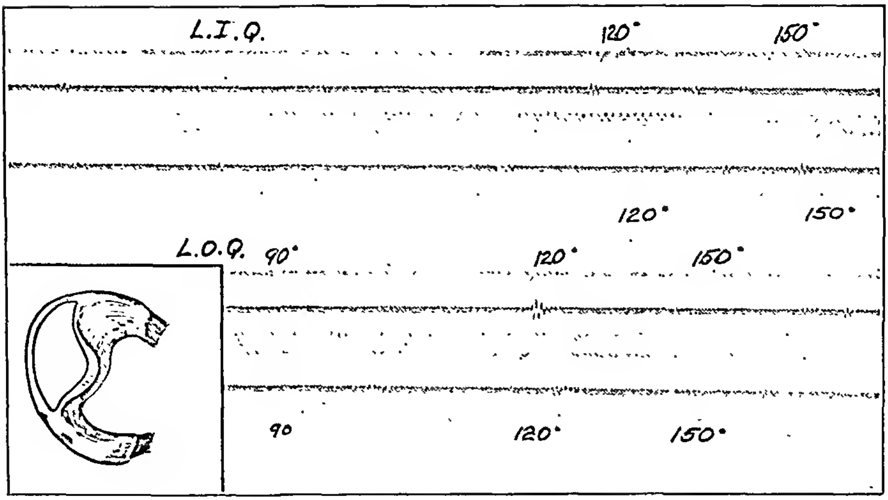

FIG. 17

Case 72. J. G. Preoperative. Injury to the internal semilunar cartilage of the right knee. The stethoscope was silent; the cardiophone recorded a dull thud in the lower inner quadrant; and the oscillogram revealed a dull thud at 120 degrees in the lower quadrants. At operation, through the Jones incision, a bucket-handle fracture of the internal cartilage was found. The auditory findings were somewhat uncertain.

findings were corroborated by operation in eleven cases. In three cases, the correlation between the auditory and the operative findings was poor. It should be noted that auditory findings are missing in cases of fracture of the semilunar cartilages with easily detachable flaps which slip in and out without great impediment.

In the majority of cases the auditory findings were of definite value in indicating not so much the type of lesion as its exact location. They were responsible for the correct choice of the small Jones incision in a number of cases.

Miscellaneous—36 Cases

The remaining cases of this series of 397 knees were classified as follows: ligamentous strain, ten cases (2.52 per cent.); synovitis, five cases (1.26 per cent.); derangement of the fat pads, eleven cases (2.77 per cent.); old fractures of the knee, three cases (0.76 per cent.); and a group which included cases of hygroma and tuberculosis and knees upon which arthroplasties had been performed, seven cases (1.76 per cent.). In this last group there was no tendency to accurate diagnostic values.

COMMENT

This report is, in a manner, preliminary, since it is the first communication on the application of sound phenomena in the locomotor system—muscles, tendons, and joints—for diagnostic purposes. The knee was selected because of its easy accessibility to sound-receiving instruments. The interpretation of sound phenomena is very difficult, because extra-

neous and extra-articular noises must be differentiated from intra-articular ones. However, it is possible to allocate certain sounds as intra-articular, because of their character and also because of the regularity of their occurrence in repeated stethoscopic, cardiophonic, and oscillographic examinations.

Sustained grating or cracking sounds in all quadrants indicate a general involvement of the joint, with arthritic changes which may or may not be the background of isolated internal derangements.

Isolated sounds are cracks, clicks, or thuds. The higher-pitched cracks indicate a harder or denser body, such as a joint mouse, while the lower clicks and the still lower thuds indicate bodies of greater softness and elasticity, such as fringes and semilunar cartilages. While we do not claim to be able to make a definite distinction between the bodies responsible for the sound, we believe that we can locate the origin of the sound both as to quadrants and as to position of the joint. In this respect, joint auscultation is a definite help, particularly in cases of injury to the semilunar cartilages.

The writer is greatly indebted to Mr. E. L. White, who directed the technical arrangement of the experiments and examinations, and also to Mr. P. Griffith, who helped with the oscillographic records. The author also gratefully acknowledges the valuable assistance of his associates, Dr. T. L. Waring, Dr. J. G. Finder, and Dr. D. M. Fuiks, in the compilation of data and in the arrangement of specimens and illustrations.

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ANATOMICAL CONSIDERATIONS RELATIVE TO RUPTURE OF THE SUPRASPINATUS TENDON

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Separation of the supraspinatus from its attachment to the humerus is a condition which has been recorded by various writers, notably by Codman of Boston, who was one of the first to recognize the prevalence and importance of the condition. There has been a general tendency to accept it clinically as the direct result of trauma without inquiring into the possibility of other etiological factors. Observations upon cadavera, in this Department and elsewhere, suggest a more wide-spread disturbance than mere rupture of a muscle.

The fact is that the rupture is very often only an accident in the course of a progressive disturbance which also involves other structures. Thus it is not surprising to find several aspects of the same condition described by different authors under various headings such as simple traumatic rupture, subacromial bursitis, or fracture of the greater tuberosity. Others have been more impressed by the disappearance of the tendon of the long head of the biceps, which so frequently occurs as a concomitant condition; still others have merely recorded the calcification which is often found in the supraspinatus tendon; while only too often the whole disturbance is classed as arthritis. It is the author's belief that a progressive disturbance, centering around the tendon of the supraspinatus, will be found to be sufficient to account for all of the different findings.

The roof of the shoulder joint consists of two very different parts: (1) a fairly stable bony arch lying above the joint; and (2) structures intervening between the arch and the joint, of which the supraspinatus is the most prominent. This muscle is in close relationship with the joint capsule below, but the tendon is separated from the bony arch above by a large subacromial bursa. This tendon is thus caught between the moving head of the humerus below and the acromial arch above, and is protected by and in contact with a synovial cavity on each side. If the tendon should rupture, communication may be established between the joint cavity and the subacromial bursa, thus adding a further complication.

Rupture of the supraspinatus tendon has been frequently recorded, especially by Codman. The disturbed conditions of the shoulder joint which he reported were, in his opinion, due entirely to unrecognized rupture of this tendon. In his experience, based upon the examination of cadavera in the dissecting room, the condition occurs in one out of every twenty subjects. In a later contribution Codman and Akerson reported that in elderly subjects (particularly in working people) the incidence of ruptured supraspinatus tendon was greater,—nearly 40 per cent. In

some cases the rupture was quite small, but in 21 per cent. of the subjects it was sufficient to permit communication between the joint and the subacromial bursa. In one of his more recent articles [3] Codman stated that he believed "that rupture of the supraspinatus tendon is the most common industrial injury causing prolonged shoulder disability . . ." In a recent analysis of cadavera, Keyes [10] reported that 17 per cent. showed partial rupture of the supraspinatus tendon.

Meyer considered the condition to be the direct result of attrition and placed especial emphasis on the disappearance of the tendon of the long head of the biceps in some of these cases. He stated that "whatever the associated conditions may be it would seem that these capsular defects result from repeated and long continued use of the arm in a position of marked abduction and external rotation . . . it would also seem that the irritation and trauma resulting from this friction might bring on a subdeltoid bursitis antecedent to the destruction of this bursa. This unavoidable trauma to the soft parts undoubtedly would also be followed by a protective reaction in the superior portion of the capsule and thus cause thickening of it. However, as soon as the capsule has been worn through near the region of the greater tuberosity, the rough surface of the latter can come in contact with the capsular portion of the long head of the biceps and begin its erosion and final destruction."

Codman and Akerson presented four hypotheses to account for the separation of the supraspinatus from its attachment to the tuberosity: (1) result of trauma (rupture and imperfect repair); (2) defects left by so called calcified deposits; (3) necrosis of tendon or other diffuse pathological process; and (4) direct result of attrition (hypothesis of Meyer).

REPORT OF TYPICAL FINDINGS

The examination of a series of 100 shoulders in the Department of Anatomy of the University of Western Ontario has revealed six cases showing a major disturbance of the anatomical relations sufficient to permit communication between the subacromial bursa and the cavity of the shoulder joint. At least a dozen others showed changes associated with the supraspinatus muscle. A brief account of some of the typical findings follows.

FIG. 1
Specimen 11.

SPECIMEN 11 (Figures 1 and 2). Right shoulder.

This shoulder is an excellent example of a moderately severe dis-

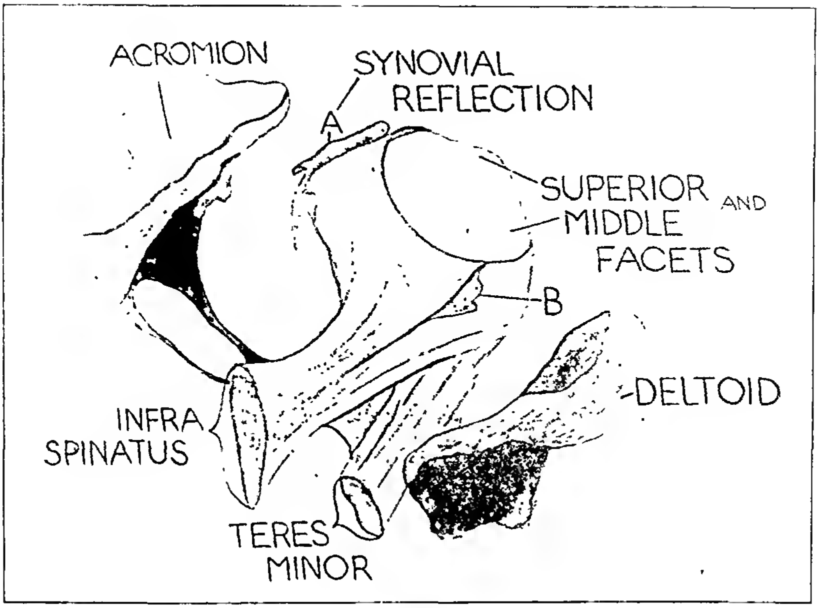

FIG. 2

A diagrammatic drawing of Specimen 11, as shown in Fig. 1. The fibrous band is clearly shown, detached from its medial connection,—*i.e.*, from the supraspinatus. At *A* and *B* can be seen the synovial reflections of the subacromial bursa.

FIG. 3

The tendon of the long head of the biceps removed from Specimen 79. The flattened condition of the upper portion and the fraying of the tendon are clearly shown.

turbance resulting from rupture of the supraspinatus tendon. The subacromial bursa is in free communication with the joint cavity. The supraspinatus ends laterally in a falciform fibrous band which is attached in front to the lesser tuberosity and behind to the posterior aspect of the middle facet on the greater tuberosity. The infraspinatus is partially involved. There is no trace of that portion of the long head of the biceps which normally passes over the head of the humerus. The long head of the biceps was found to arise in the upper part of the intertubercular sulcus. It had no apparent connection with the falciform band.

SPECIMENS 78 and 79

These were the right and left shoulders of the same subject. They presented a similar amount of disturbance. The supraspinatus and infraspinatus joined at their insertion by means of an aponeurotic sheet, in the lateral part of which a small V-shaped slit afforded free communication between the subdeltoid bursa and the joint cavity. On the left side the tendon of the long head of the biceps was quite flattened over the head of the humerus and very frayed along the edges (Fig. 3). In addition there were several synovial fringes in the joint, especially one along the biceps tendon. In this

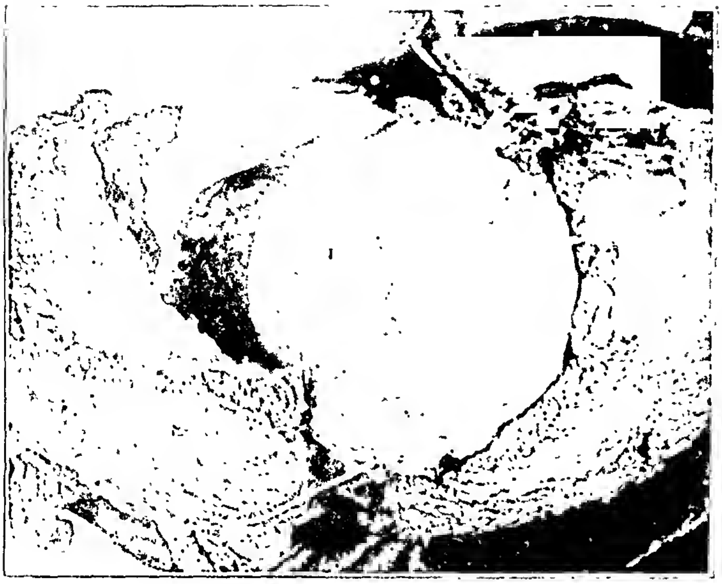

FIG. 4

Specimen 23. The deltoid has been reflected and the bursa opened up. Note the edge of the fibrous band and the irregular appearance of the bone.

specimen, which suggested eventual disappearance of the biceps tendon, particular attention was paid to the condition of the intertubercular sulcus. Here the bone was found to show a number of small depressions or pits to which strands of fibrous tissue passed from the tendon. These small secondary anchorages of the tendon in the sulcus possibly indicate the first steps in the securing of a permanent secondary attachment prior to the disappearance of the upper part of the tendon.

SPECIMEN 23 (Figure 4) Right shoulder.

This is similar to Specimen 11. The upper part of the biceps tendon is gone and the new origin is from a prominent knob on the side of the lesser tuberosity. The illustration shows the general nature of the bony changes taking place around the exposed tuberosities and the intertubercular sulcus, and indicates the increasing difficulty which surrounds the movement of the biceps tendon through the sulcus up to the time of the new secondary attachment and disappearance of the upper portion.

SPECIMEN 28 (Figures 5 and 6). Left shoulder.

This shoulder presented the most extreme example of the disturbance encountered in the series. The subacromial bursa was greatly enlarged and there was no apparent separation between it and the joint cavity. The articular surface of the head of the humerus extended continuously over the greater tuberosity and it was quite apparent that the tuberosity had been articulating with the inferior aspect of the acromion process. This latter showed a smooth, polished surface, about three-quarters of an inch in diameter, on its inferior aspect.

The supraspinatus and infraspinatus muscles ended laterally in a continuous fibrous band which appeared as a falciform fold in the medial wall of the enlarged synovial cavity just above the glenoid lip. This was the greatest amount of retraction of these muscles found in any specimen. The upper portion of the tendon of the long head of the biceps was missing and the head was found arising from the lateral aspect of the lesser tuberosity. The tendon of the subscapularis was thin and small and attached to the inferomedial aspect of the lesser tuberosity. It created a fold in the anterior part of the capsule along which synovial fringes were present.

In addition to these five specimens described, a sixth case, not quite as marked as Specimen 23 but similar in character, was found.

During the examination of the shoulders of this series it was noted that a number of cases exhibited what appeared to be a change from the normal character of the supraspinatus and, to a lesser extent, of the infraspinatus. This change consisted of a loss of the muscular or fleshy nature of the supraspinatus as it passed over the shoulder joint. In these cases

Fig. 5
Specimen 28.

the superior aspect of the shoulder joint appeared to be covered by an aponeurotic sheet into which the supraspinatus and infraspinatus muscles blended. In two cases this sheet was extensive enough to approach the subscapularis tendon on the one side and to involve the teres minor on the other. In two other cases calcified deposits were found in these aponeurotic sheets, near the attachment to the greater tuberosity. The changed character of the muscle tendons in these cases raised the question of the normal condition of the supraspinatus in its relation to the shoulder joint.

ANATOMY AND PHYSIOLOGY

Examination of standard works on anatomy discloses the unqualified statement that the supraspinatus is inserted by a tendon into the upper of the three facets on the greater tuberosity of the humerus. In some texts, no mention is made of any attachment to the capsule of the shoulder joint; in others, it is mentioned; while in some the tendon is said to be intimately attached to the capsule. In the case of the infraspinatus only its insertion into the middle facet is mentioned, and no indication of the possibility of its attachment to the capsule is suggested.

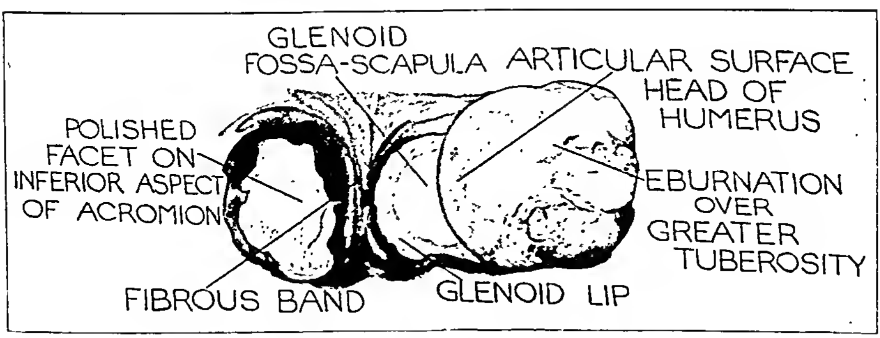

Fig. 6

A diagrammatic drawing of Specimen 28, as shown in Fig. 5. The extreme conditions shown in this specimen represent the end stages of the disturbance. Note the condition of the humerus, especially the area of the greater tuberosity and the polished facet on the under surface of the acromion. Observe also the position of the fibrous band between the acromion and the glenoid lip. This is the band into which the supraspinatus and infraspinatus were inserted.

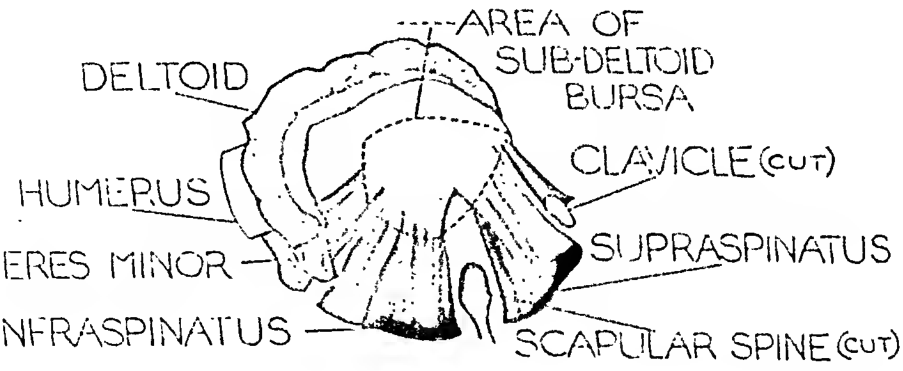

FIG. 7

A diagrammatic drawing illustrating how the insertions of the supraspinatus, infraspinatus, and teres minor may blend together during the first stage, forming an aponeurotic sheet which is closely fused with the capsule of the shoulder joint. The subdeltoid bursa usually extends over the same area, as is shown by the dotted line.

In order to obtain a starting point for the determination of the normal condition of the muscle, a number of shoulders of stillborn infants were examined. These shoulders indicate that the supraspinatus and infraspinatus are normally fleshy right up to the point of insertion, a very short fibrous tendon forming the terminal portion. As older and more mature shoulders are inspected, it becomes increasingly evident that the lateral fibrous portion tends to increase in amount.

The interval between the supraspinatus and infraspinatus is normally filled in with connective tissue, so that no hollow exists between the two tendons. As they become more fibrous, the intervening connective tissue seems to become identified with the fibrous portions of the muscles, and the whole gradually forms a thick aponeurotic sheet over the shoulder joint. This change from a fleshy muscle to an aponeurotic sheet continues until all of the muscle which is in contact with the joint capsule has been altered. Attachment to the joint capsule follows this change and the amount of attachment is directly proportional to the amount of aponeurosis of the muscle insertion. Similarly the area of the subacromial bursa appears to follow the spread of the aponeurotic portion of the muscle, so that the area of the bursa is practically that of the fibrous sheet. The findings of the dissecting room thus suggest a progressive change in the character of that part of the muscle which lies in contact with the joint capsule. This change produces an aponeurotic sheet which is closely connected with a synovial cavity above and below. (See Figure 7.)

The attachment of this sheet to the greater tuberosity appears to be a matter of some variation, depending on the size of the sheet. It may include both the superior and middle facets or only a portion of them. The attachment may be reduced to a line along the outer edge of the tuberosity. When the attachment is more lateral, the synovial lining of the joint tends to follow as far as possible, so that a portion of the greater tuberosity may become covered by synovial membrane.

In order to comprehend what has been happening to the supraspi-

natus muscle we must turn to a consideration of its physiology, for function is the determinative factor in structure.

From the position of the supraspinatus, it is evident that it is conveniently placed to assist in the movement of abduction. According to various writers the muscle is concerned with the first stage of abduction only, raising the arm some 15 or 20 degrees. Codman and Stevens agree that the first stage of abduction is due to the supraspinatus, but Stevens considers that it acts through about 30 degrees. The deltoid then continues the movement, being incapable of initiating the movement of abduction. In support of this we have been referred to a patient suffering from a stab wound which severed the nerve supply to the supraspinatus. This individual was subsequently unable to initiate the movement of abduction in the usual way (although the deltoid was uninjured) and had to resort to one of two expedients,—by bending the trunk and swinging the arm or by giving the arm a push with the other hand, he got it out to the point where the deltoid was able to carry on.

From the standpoint of leverage, it may be pointed out that the supraspinatus has less and less advantage as abduction proceeds and that it would, therefore, be at its best during the early stages. During these early stages of abduction, the reverse is true of the deltoid. It has no angle of leverage at all with the arm at the side. The action of the deltoid at this stage would, therefore, be a pull in the direction of the long axis of the humerus. This would bring the upper end of the humerus against the acromial arch and compress the intervening supraspinatus. Thus the supraspinatus is pulling medially between two bony surfaces which are compressing it at the same time. If this continual "ironing" or "rolling" takes place frequently and over a long time, or if it is accompanied by additional pressure, it must in time have a profound effect upon the tendon.

Several protective mechanisms operate to protect the supraspinatus. In the first place, the large and constant subacromial bursa intervenes between the supraspinatus and the bony arch above. This bursa acts as a cushion against the upward thrust of the humerus. Once the supraspinatus has passed medially, the bursa continues to act between the tuberosity and the acromion. In connection with the bursa there has been an almost constant finding of a fibrous expansion from the tendon of the short head of the biceps which occupies the angle between the short head of the biceps and the coraco-acromial ligament. This serves to strengthen the superior wall of the bursa. The long head of the biceps may have some part in opposing the upward thrust of the humerus.

There must be noted also the action of the short rotators as pointed out by Stevens. As the movement of abduction progresses, the short rotator muscles (subscapularis, infraspinatus, and teres minor) acting together resist the upward thrust without affecting the direction of the movement (since the sum of the pull of the lateral rotators balances the sum of the medial). Martin has stated that the latter stage of abduction is accompanied by some lateral rotation of the humerus, but he considers

it to be due to the contact of the tuberosity with the under surface of the acromion.

FURTHER STRUCTURAL DISTURBANCES

The gradual change in the supraspinatus from the fleshy character of the infantile muscle to the aponeurotic insertion of the middle-aged might possibly be considered as a normal alteration due to use. However, it brings about several secondary changes which cannot be considered as normal. Moreover the change in the supraspinatus is probably not developed quickly except under conditions of frequent abduction or continued pressure. Some of the other changes will be discussed briefly.

Fusion of Aponeurosis and Joint Capsule

The protection of the superior aspect of the joint capsule having been diminished by the thinning of the related portion of the supraspinatus and its change from a fleshy character to an aponeurosis, there is invariably a fusion of the aponeurosis with the capsule. One result of this fusion is that the capsule is drawn medially by the action of the supraspinatus during abduction, so that there is little chance that the capsule would be nipped or pinched in a fold. If the fusion did not occur, it is probable that a small bursa would be formed between the joint capsule and the aponeurosis. Such a bursa has been described, but the author has never seen it; in all of his cases fusion was complete.

Calcified Deposits in the Aponeurotic Sheet

Calcified deposits have been frequently observed by various authors in the aponeurotic tendon close to the greater tuberosity. These may be identified in roentgenograms and, if close to the tuberosity, they may be mistaken for slight fractures of the tuberosity. Codman and Wright studied the pathology of these calcified deposits and came to the conclusion that they resulted from slight injuries to the tendon with an abortive attempt at repair in a tissue possessing but little blood supply. Brickner and Moschowitz arrived at a similar conclusion[1]. Elmslie agreed that this was the most likely explanation. Carnett, after opening fourteen shoulders with calcified deposits, recorded his impression that in none of his cases was it due to rupture of the tendon fibers. Harbin, in discussing calcium salts in tendons, noted that the blood supply of the tendon was poor and considered it probable that frequently repeated mild trauma might occur as the result of impingement of the tendon against the inferior surface of the acromion during abduction, with resulting necrosis and calcification. He further noted examples cited by Schujenioff who found lime salt deposited in muscle fibers thirty-six hours after suture of a divided muscle. Harbin was definitely of the opinion that severe trauma was not the cause of the condition.

The deposits of calcium may be single or multiple and may be unilateral or bilateral (Carnett). They vary in size and may occupy different

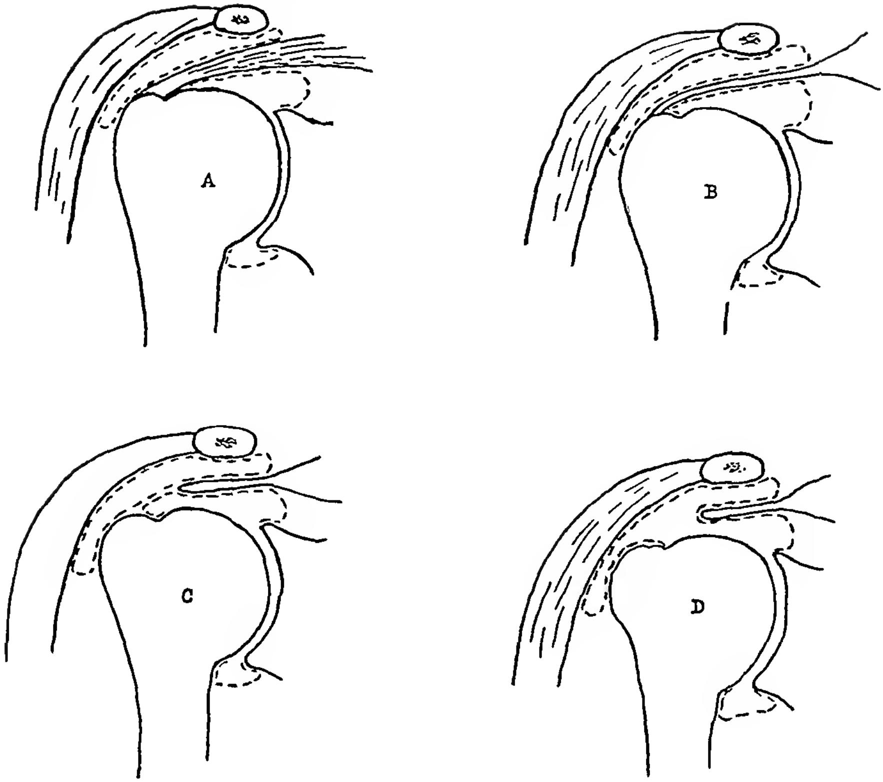

FIG. 8

Diagrammatic drawings representing four stages in the development of the condition:
A: Normal;
B: Aponeurotic sheet fused with capsule;
C: Separation of the aponeurotic sheet from the tuberosity;
D: Communication established between the joint cavity and the bursa.

positions. In the shoulders examined in this series, calcified deposits were found only twice, and in both cases the insertion of the supraspinatus was in the form of an aponeurotic sheet. The deposits were both close to the attachment to the tuberosity.

It is suggested that these calcified deposits occur at a definite period in the development of the condition which is under consideration. They occur after the creation of the aponeurotic sheet at a time just antecedent to that when separation of the fibers is likely to occur. Codman and Akerson suggested that the disappearance of calcium deposits was one of the possible ways for defects in the tendon to occur.

Disappearance of the Tendon of the Long Head of the Biceps

The same causes which have operated to produce changes in the supraspinatus have undoubtedly had their effect upon the tendon of the long head of the biceps. The tendon from Specimen 79 (Fig. 3) illustrates the first stage. The tendon becomes flattened, thin, and frayed along its edges. As the tendon weakens, secondary attachments are formed in the

intertubercular sulcus, so that when the upper part eventually disappears a new attachment is ready. The third and final stage of disappearance of the capsular portion of the tendon is probably not completed until communication is established between the joint cavity and the subacromial bursa.

Rupture of the Aponeurotic Tendon

It matters little whether separation of the aponeurotic insertion of the supraspinatus occurs as a result of previous calcification, splitting of the fibrous sheet, or sudden rupture due to trauma. The essential point which the writer wishes to make is that the formation of the aponeurotic sheet is a preliminary stage antecedent to separation. Once separation has occurred, the continued action of the supraspinatus will obviously cause the defect to increase and, as the synovial lining of the joint cavity and the subacromial bursa come into contact, the pressure effect will soon break down the partition and create a condition of free communication between joint and bursa. (See Figure 8.)

Fig. 9-A

Fig. 9-B

A normal shoulder in a young adult male.

At first there is some fibrillation and shredding of the tendon with irregular tags of fibrous tissue remaining attached to the greater tuberosity. Gradually these shreds of tissue are absorbed and disappear, and the free edge of the retracting supraspinatus tendon becomes smooth and regular and presents a falciform edge, the horns of which are attached anteriorly and posteriorly to extremities on the greater tuberosity. (See Figures 1 and 2.) In Specimen 28, the most extreme example of this condition, all connection of the supraspinatus with the tuberosity has been lost.

Bony Changes

FIG. 10

The shoulder of a painter, showing some change in contour of the greater tuberosity and lessening of the interval between the humerus and the acromion. Compare with Figs. 9-A and 9-B. Note also absorption shadows in the region of the greater tuberosity.

The most marked bony changes occur in that portion of the greater tuberosity which has been laid bare by the retraction of the supraspinatus. The bony surface becomes rough, irregular, and pitted. If the condition proceeds to the extreme represented by Specimen 28, this surface of the greater tuberosity may become smooth again, due to rubbing against the under surface of the acromion.

As might be expected, the bony changes which take place in the greater tuberosity and in the intertubercular sulcus are often reflected on dried and disarticulated bones. Examination of seventy humeri in the Department of Anatomy gave the following results:

Normal	48 cases
Changes in tuberosity alone	12 cases
Changes in sulcus alone	2 cases
Changes in both	5 cases
Changes obviously due to arthritis	3 cases
Total	70 cases

It will be observed that the majority of changes were noted in the region of the greater tuberosity and that this area was affected seventeen times in the seventy bones. This is an occurrence of about 24 per cent. In the bones where changes were present both in the tuberosity and in the sulcus, it was quite apparent that the upper part of the tuberosity had been unoccupied and that no tendon of the biceps could possibly have been working through the intertubercular sulcus.

ETIOLOGICAL FACTORS

The condition appears to be a gradual and progressive change centering about the supraspinatus muscle and the movement of abduction. Several factors combine to produce this effect. Since the condition is primarily associated with the movement of abduction, there is an occupational factor when the individual is engaged in an activity which requires frequent abduction or which necessitates working with the arm in an ab-

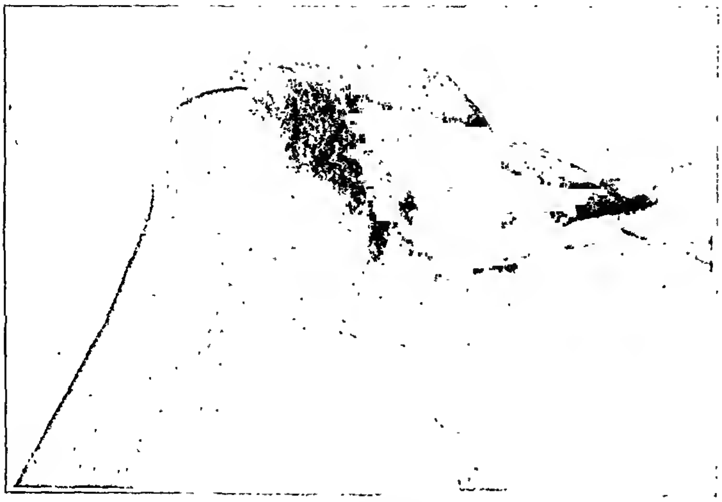

Fig. 11
Specimen 28.

ducted position. Another factor would be continued pressure such as occurs in the act of scrubbing a floor.

Since time is required to develop the changes which are necessarily antecedent to separation, the condition is not liable to occur in young people. Codman stated that he had never found a rupture of the supraspinatus tendon in a patient under twenty years. The average age in his series of 122 was fifty-three years. The average age of the six cases reported here could not be determined exactly; it lay between fifty-five and sixty. These figures apply to the cases where progressive change preceded separation. It is possible, of course, for direct violence to rupture any muscle, the supraspinatus not excepted. Fractures of the greater tuberosity also occur as a result of direct violence. This type of injury is not within the scope of this paper.

In the history of these cases there may or may not be a history of injury. Where thinning of the tendon has taken place, it is possible to have either partial or complete separation with a very small amount of violence. Where a history of injury is obtained, it is usually definitely associated with abduction, as, for instance, in the case of a woman throwing a heavy wet blanket over a line. Wilson recorded the case of a man who ruptured the supraspinatus by throwing a heavy stone out of a trench. Definite histories of this type are, however, uncommon. Many cases occur during a fall or misstep when the patient throws up an arm to retain his balance or to seize some support. The occupational history is important. Wilson reported the case of a patient who was engaged in folding heavy woolen cloth, a task necessitating abduction and external rotation of the right shoulder. He had performed this task many times daily during a period of six years.

PHYSICAL DIAGNOSIS

While the history is of great importance in making a diagnosis, there are one or two physical signs which may be noted. First, there is Dawbarn's sign. This sign is present in any case which presents a tender point over the greater tuberosity. Thus fracture, bursitis, and rupture of the supraspinatus tendon may all present this diagnostic sign. It consists in disappearance of the tender point in full abduction, due to the fact that the painful part has been carried in under the acromion process. Fracture

of the tuberosity may be eliminated by roentgenographic examination. In acute bursitis, active and passive abduction are both painful; in rupture of the supraspinatus, passive abduction is less liable to cause pain.

A later sequela in more pronounced cases may be represented by partial atrophy of the supraspinatus and infraspinatus. This has been described by Codman and results in increased prominence of the spine of the scapula.

A point which may be recalled at this time is that the condition is sometimes bilateral. This is difficult to explain on the basis of injury alone without previous change in the supraspinatus.

The rôle of the roentgenographic examination in the diagnosis of this condition, while not conclusive, is nevertheless of considerable importance. As has already been noted, it is necessary in differentiating this affection from fracture of the greater tuberosity. Direct results of attrition, however, may be noted under three heads.

The first thing to look for is the occurrence of calcified deposits in the insertion of the supraspinatus. Such deposits are direct evidence of the presence of the progressive change which leads to separation.

The second and more constant finding to be watched for is the occurrence of slight absorption shadows and irregularities in the greater tuberosity itself. (See Figure 10.) Such shadows have been found in both suspected and proved cases. They usually consist of one or two small dark areas of absorption near the crest of the greater tuberosity. Their occurrence is very significant. In extreme cases the roentgenographic findings are very definite as there is a change in the entire contour of the upper end of the humerus. (See Figure 11.)

The third point to be looked for in the roentgenograms is the amount of interval existing between the head of the humerus and the acromion. In order to make any accurate comparison of this interval it is necessary to work out an exact technique, so that the same relative angle may be employed in all cases. It is also important to compare both shoulders. Thinning or disappearance of the intervening supraspinatus muscle of course reduces the interval.

TREATMENT

It is not the purpose of this article to discuss treatment in detail. In the earlier stages the value of local treatment should be debated, especially horizontal splintage to provide rest for a weakened tendon. No method of local treatment, however, will be completely successful if there is an occupational factor which has been disregarded.

Various forms of operative procedure have been discussed by Codman, Carnett, Harbin, Wilson, and Fowler, and probably by many others. Operative procedures as described seem more applicable to acute traumatic rupture of an unimpaired tendon than to cases with a chronic background. The possibility of reparative procedures in those old cases where

fibrous change in the tendon has been followed by rupture and retraction is something to be debated by the surgeons.

SUMMARY AND CONCLUSIONS

The normal anatomical relations and the physiological action of the supraspinatus muscle in the movement of abduction are such that frequent and continued action may produce a profound change in the character of the muscle.

The change in the muscle consists essentially of an alteration in the character of its lateral portion,—from fleshy fibers ending in a short tendon to a wide aponeurosis of fibrous tissue which blends with the infraspinatus.

Once the muscle has been weakened by this alteration, a series of other changes become imminent possibilities. These include calcification, splitting or rupture of the tendon, separation of the sheet from the greater tuberosity, and the establishment of free communication between the subacromial bursa and the joint cavity.

Associated and subsequent changes occur in the greater tuberosity, in the intertubercular sulcus, in the articular cartilage, in the tendon of the long head of the biceps, and in the walls of the joint cavity.

The long head of the biceps (capsular portion of the tendon) is at first flattened and frayed. Eventual disappearance of this portion is not uncommon.

The purpose of this communication is to emphasize the fact that these results are not caused by sudden acute ruptures of the supraspinatus, but are preceded by a long preliminary wearing effect on the tendon of the supraspinatus. On this account the age of the patient and the type of occupation are important etiological factors.

From all figures available it would appear that about 20 per cent. of all adult shoulders show some degree of change in the supraspinatus. Further, about one-quarter of this 20 per cent. will suffer some degree of rupture or splitting. On this basis, the condition as described constitutes the most common form of shoulder disability. Comparison of these figures with the number of cases reported suggests that many of these shoulders are undiagnosed and untreated.

The author wishes to express his thanks to the X-Ray Department of Victoria Hospital, London, for their assistance.

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TENDINOPLASTY OF THE FLEXOR TENDONS OF THE HAND

USE OF TUNICA VAGINALIS IN RECONSTRUCTING TENDON SHEATHS *

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One of the difficult problems in surgery of the extremities is the restoration of motion to a hand, following injury to the flexor tendons of the fingers. The use of foreign material to form a sheath in an attempt to prevent adhesions between the tendon and its adjacent tissues has not met with success. Cargile membrane, silver foil, oily pastes, segments of veins, and fascia lata have alike proved unsuccessful. More success has followed the use of tunica vaginalis as a transplant to form a new tendon sheath similar in structure and function to the normal tendon sheath. Unfortunately this autotransplant is available only in males.

The tunica vaginalis is a thin, membranous structure made up of two layers,—the inner one, formed by a single layer of flattened endothelial cells, and the outer one, composed of fibrous connective tissue containing elastic fibers. The presence of the elastic fibers permits the distention of the tunica vaginalis to a marked degree. This thin membrane is easy to work with when held by sutures at the four corners. It is strong and elastic, and apparently, when transplanted, retains its ability to secrete a serous fluid. Unfortunately, like the peritoneum, it tends to form adhesions where it is traumatized. Fortunately, however, the elastic fibers permit movement of the underlying tendon even in the presence of moderate adhesions. In this respect, tunica vaginalis differs from fascia lata or other types of membranous transplants which are not elastic.

The serous lining of endothelial cells of the tunica vaginalis apparently secretes a fluid when transplanted, just as it does *in situ*, when traumatized, by the formation of a hydrocele. It is likely that the fluid aids in preventing adhesions between it and the tendon which it surrounds. It probably also acts as a lubricant to the sliding tendon. Unfortunately, it is not capable by itself of preventing the formation of adhesions, so that active motion of the finger must be started early. Adhesions form very quickly in traumatized peritoneum, and it is probable that they form as quickly in transplanted tissues of identical structure. For this reason, the fingers must not be splinted, but should be mobilized the second day after operation. If a splint is applied to the dorsum of the forearm and hand, holding the wrist in flexion, and if the tendons have been carefully sutured with silk, passive motion without force in the direction of flexion may be started immediately after operation in order to prevent limiting

* The cases included in this paper are from the United States Public Health Service, Division of Marine Hospitals. The experimental work was done at the University of Maryland School of Medicine and College of Physicians and Surgeons.

adhesions. As soon as the incisions are healed, hydrotherapy, followed by active and passive motion, may help to prevent stiffness and may aid in the loosening up process which is invariably required in all cases of tendon suture.

During the course of other experiments on dogs, the tunica vaginalis was removed from the testicle and placed about the tendon of the leg to form a tendon sheath.[2] The newly formed tendon sheath was sutured to the paratenon, encircling the tendon loosely. The secreting layer of tunica vaginalis was placed next to the tendon. This operation was performed on five dogs and they were observed for a period of four months. It was found that the transplanted tunica vaginalis lived and grew although not without adhesions to the tendon. Adhesions formed, although the dogs were permitted to walk on the operated legs from the time of the operation. As far as could be determined, the adhesions did not tend to limit the motion of the tendons.

In the human being tunica vaginalis was first used in 1929 to reconstruct a tendon sheath. In this case, the patient had a badly lacerated hand; the flexor tendons of the second and third fingers had been cut and infection had followed. When seen by the author, the case was of some months' standing. The tendons had not been sutured at the time of injury. At operation, through a lateral incision, it was found that no tendon sheaths remained in the fingers and that the tendons had contracted into the palmar region. The flexor digitorum profundus was reconstructed and tunica vaginalis, the length of the finger, was used for reconstruction of the tendon sheath. The technique for the tendon repair was that advocated by Bunnell.

For the removal of the tunica vaginalis a high incision is made just below the external inguinal ring. The testicle is made to present through this incision. If four sutures of silk are placed in the tunica vaginalis near the line of proposed incision, before it is removed from the testicle, it can be handled with more ease and with less trauma than is possible with the use of forceps. It should be remembered that wherever the membrane is traumatized by forceps there is potential danger of the formation of adhesions.

In difficult cases with destruction of the tendon sheaths and with adherent roughened tendons, it has frequently seemed advisable in the past to excise this roughened adherent tendon and to suture in its place a transplanted tendon. With the use of a smooth, secreting, transplanted tendon sheath, it is believed that many of these roughened tendons can be carefully dissected free and made to function again without resorting to the more difficult operation of tendon resection and tendon transplantation. For the average case, sufficient tunica vaginalis may be removed from one testicle to reconstruct the tendon sheaths of two fingers. The size of the piece which can be removed varies of course with the size of the testicle. A piece, two by two and a half inches, can usually be obtained without previous distention of the tunica vaginalis.

The tunica vaginalis was cut so that it could be inserted below the tendon and between the pulleys. It was sutured laterally with interrupted silk. The tunica vaginalis was then brought over the tendon and the edges were sutured together with interrupted silk, which also anchored it to the subcutaneous tissues of the fingers. (See Figure 1.) A sufficient number of sutures were placed so that as far as possible the tunica vaginalis would be in contact with the subcutaneous tissues of the finger and not with the tendon, so that it would adhere and derive its new blood supply from the subcutaneous tissues. The diameter of the newly formed sheath was approximately twice the diameter of the tendon. The secreting serous layer was turned in toward the tendon.

The results were satisfactory, although it was evident that some adhesions had formed; however, with continued use of physiotherapy, these adhesions did not permanently limit motion.

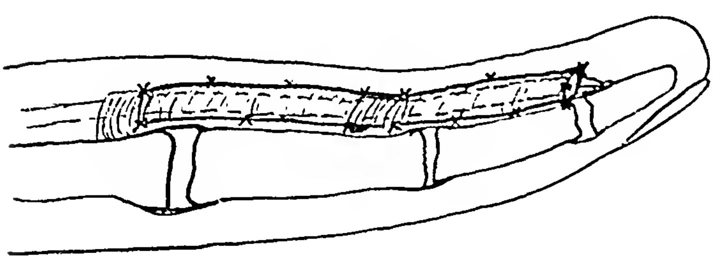

Fig. 1

Reconstruction of the tendon sheath through lateral incisions in the finger. The new sheath of tunica vaginalis is anchored to the soft tissues by interrupted silk sutures.

Since this case, tunica vaginalis has been used in six patients with good results.

Case 1. The patient was a male, twenty-eight years old, who, some months previously, had received an injury to the right hand, which had severed the flexor tendons of the second and third fingers. The injury was followed by a severe infection. At the time of operation there was loss of function of the flexor tendons of the two fingers. The joints had been kept in fair condition by daily movements, and the blood supply to the injured fingers had not been impaired. After repair of the tendons, the sheath was reconstructed with tunica vaginalis. Motion was started on the third day and was continued as long as progress was made. The final result was a range of motion from full extension to a degree of flexion, so that an object the size of a broomstick could be grasped firmly by the injured fingers. This is a loss of approximately 20 per cent. from the normal range of flexion.

Case 2. A male, twenty-two years old, had received an injury to the right index finger six months previous to admission. The flexor tendon had been cut and a severe infection had followed. The cut tendon was reconstructed and the tunica vaginalis was removed from the right testicle to form the new tendon sheath. Motion was started on the third postoperative day. The final result was a range of motion from full extension to moderate flexion, with a loss of flexion in the two phalangeal joints, amounting to about 25 per cent.

Case 3. A male, twenty-four years old, four months previously, had received a lacerated wound of the third finger of the right hand with subsequent infection. He had been unable to flex the middle finger since the injury. After the tendon had been sutured, a sheath was reconstructed from tunica vaginalis removed from the right testicle. The final result was a range of motion from full extension to nearly complete flexion.

Case 4. A male, thirty-eight years old, had received a severe injury to the right hand, necessitating the loss of the fourth and fifth fingers and the tips of the second and third fingers. The tendons of the second finger were lacerated. There was loss of

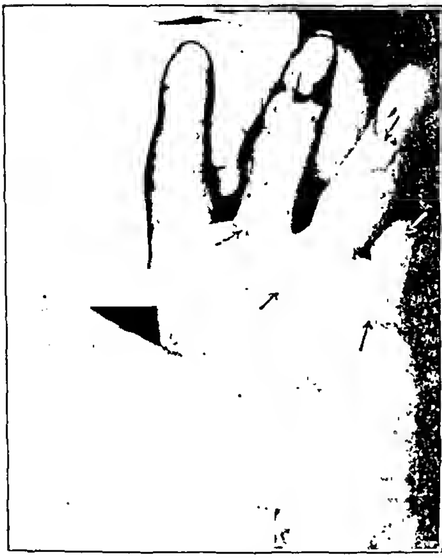

FIG. 2
Case 5. Extent of the grafted area.

FIG. 3
Case 5. Full extension of fingers.

flexion in the second finger and very little motion was present in the third. After repair of the flexor tendon of the index finger, the sheath was reconstructed from tunica vaginalis. The results were fair,—a range of motion from full extension to about 50 per cent. of normal flexion.

FIG. 4
Case 5. Full flexion of fingers.

CASE 5. A male, thirty-six years old, in childhood had suffered a severe burn of the hand, resulting in the loss of the terminal phalanges of the little finger. The third, fourth, and fifth fingers had grown to the palm of the hand. After the fingers had been freed from the scar, and after the tendons had been lengthened at the wrist, a pedicled skin flap from the abdomen was used to cover the denuded area of the palm and fingers. The result was satisfactory except that there was little motion in the fingers, due to the long period of fixation necessitated by the skin grafting. Later, the skin graft was elevated, the tendons were freed, and the tendon sheaths were reconstructed from the tunica vaginalis. The results are shown in Figures 2, 3, and 4.

CASE 6. A male, twenty-three years old, had received an injury to the middle finger of the right hand, resulting in inability to flex the finger. Two months after the infection had subsided, the tendon was repaired and the sheath was reconstructed from tunica vaginalis. Motion was started on the third postoperative day. The final result was a range of motion from full extension to nearly complete flexion.

The author has not found that reconstruction of tendon sheaths from tunica vaginalis is ideal, but he believes that it is superior to other materials which have been used.

SUMMARY

The restoration of function to a hand with adherent or destroyed

flexor tendons and tendon sheaths is difficult and often unsatisfactory. Foreign materials, used to form a sheath or to prevent adhesions, have not been found satisfactory. In the finger there is not room for a free transplant of paratendinous fat which has been used with success in other locations.

For the reconstruction of a tendon sheath, tunica vaginalis is superior to other tissues which have been used. Histologically and functionally it resembles the thin, secreting membrane which normally encloses the flexor tendons of the fingers. Early motion is as essential as careful suturing in the reconstruction of flexor tendons and tendon sheaths.

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ARTHROTOMY FOR INTERNAL DERANGEMENT OF THE KNEE *

BY PAUL PLUMMER SWETT, M.D., HARTFORD, CONNECTICUT

That there is no universal standard of management in the operative treatment of internal derangement of the knee is conclusively demonstrated by the wide variation in the ten articles on the subject, by writers from different countries, which were published in *The Journal of Bone and Joint Surgery* for April 1932. It is the object of this paper to report upon the method which the author has consistently followed for several years. It is not intended to add to the confusion, but it is hoped that this modest series of cases treated along definite lines may show that this procedure, consistently adhered to and meticulously carried out, may be looked upon as one example of a standard method.

This plan of operative treatment is based upon certain clear-cut principles, designed to secure the maximum of benefit by emphasizing rigid asepsis, adequate exposure of the knee joint, and non-meddlesome postoperative care.

ASEPSIS

The leg is shaved from the foot to the groin the afternoon before the operation. The entire shaved area is then scrubbed with soap and water and with alcohol. Sterile towels are next loosely bandaged around the extremity and left in place until the patient is anaesthetized. No attempt is made to sterilize the skin below the ankle, because it is liable to prove a source of contamination. The foot, of course, is well cleaned.

After the patient has been anaesthetized, the operator, or a competent assistant, who has been scrubbed, masked, and gloved, scrubs the leg from the ankle to the groin with benzine. He then wipes off the benzine with dry sterile gauze and paints the area with a 4-per-cent. tincture of iodine, which is left on. A sterile sheet is laid under the leg up to the groin, and the foot is wrapped in a sterile towel, which is secured by a thick, wide, gauze spica bandage, extending from the toes to the tibial tubercle. Another sterile sheet is draped over the patient, from the knee to the neck, and this sheet is clipped, on each side of the leg just above the knee, to the sheet upon which the leg lies.

The foot of the table is then dropped to allow the knee to flex to a right angle. The operator seats himself on a stool at the foot of the table, so that the patient's foot is easily supported on the operator's thigh, permitting him to increase or to decrease the flexion of the patient's knee without touching it with his hands,—merely by shifting the position of his own thigh and leg. An assistant stands at each side of the table, facing the knee laterally.

* Read by title at the Annual Meeting of the American Orthopaedic Association, Milwaukee, Wisconsin, May 21, 1936.

The skin incision is made; the bleeders are picked up without sponging; and the skin towels are applied, so that no skin is exposed to the sight or to the touch. The soft-tissue layers are opened down to the synovial layer by sharp dissection, using ordinary gauze wipes, applied by hand. After the synovial layer has been reached, all further sponging is done with small, dry, compact, gauze sponges which are picked up by the nurse with artery forceps and handed to the operator without letting the wipe come into contact with anyone's hand. At the risk of possible irritation, dry wipes are preferred to wet sponges which require squeezing. At no time is anything put into the knee except these sponges or the instruments, and rarely, if ever, are ties used inside the joint. The exposure is planned to permit adequate visibility and to give space for the required manoeuvers without trauma to the tissues. As soon as the corrective procedure has been completed, the synovial layer is closed with a continuous No. 1 chromic suture, and a small, thin, rubber tissue drain is left just within the joint at the lower end of the incision. The drain is used to prevent the accumulation of an extensive blood clot. It is thought to be safer to do this than to prolong the procedure within the joint by a too protracted effort to stop all the oozing. The free end of the drain is secured by a safety pin, and this is caught through a slit in the wide and long first layer of the gauze dressing which is wet with alcohol. At the end of forty-eight hours, the drain is easily removed by lifting off this dressing; usually, it is not even necessary to touch the drain with the forceps in removing it.

EXPOSURE

Adequate exposure is taken to mean such access to the knee joint as permits full visibility of the lesion or lesions, exploration of all parts of the joint, and room to deal with such lesions as are found. These objects are attained by an incision at the antero-internal aspect, parallel to the patella tendon, beginning slightly above the level of the tibial tubercle and about an inch medial to it, and extending upward slightly medial to the patella to about the level of the middle of the patella. This incision is customary, regardless of the expected lesion, except in the rare cases of a loose body, which is known to be solitary and which can readily be located and dependably localized at some particular place. Through this incision, then, one is able to explore the internal meniscus, the medial joint margins, the infrapatellar pad, the alar ligaments, the crucial ligaments, and the under surface of the internal condyle. If in these locations there is found pathology sufficient to account for the patient's signs and symptoms, no further exposure is required. If, however, no lesions in these regions are found, or if there is any doubt about their adequacy to explain the symptoms, the incision is extended upward along the medial border of the patella and the quadriceps tendon for a distance sufficient to permit a lateral displacement of the patella to the outer side of the external condyle. This exposure affords a comprehensive view of

the external condyle, the external meniscus, and the outer part of the tibial head.

POSTOPERATIVE CARE

The postoperative plan begins with the closure of the skin incision, and the first step is to support the knee firmly without immobilizing it. For this purpose, bulky bandages of folded gauze—about sixteen layers deep, six inches wide, and from four to eight yards long—are snugly wound around the knee in a figure-of-eight, extending from the midleg to the midthigh. The lower extremity is supported over a firm pillow, laid lengthwise under the leg and thigh, so as to permit about 10 degrees of flexion at the knee. The patient is then returned to a bed made rigid by a fracture board, so that the springs cannot sag. The importance of a rigid bed can hardly be overestimated, since it permits the patient to relax more completely, thus preventing painful spastic contractions of the thigh muscles.

From this time on, the patient is permitted to move the knee at will; no passive movements are permitted, and no schedule of voluntary movement is ordered, except that active contraction of the quadriceps is permitted and encouraged as soon as the patient is willing to begin. No special emphasis is directed toward non-weight-lifting contraction until the end of eight or ten days; then, if the pain and effusion are well in hand, such movement is insisted upon several times each day.

The patient is kept in bed for from eight to ten days, depending upon the amount of discomfort. The drain is removed forty-eight hours after the operation, and the original type of dressing is reapplied. The stitches are removed usually on the seventh postoperative day. At that time a wide, bulky, snug bandage of semi-elastic material is applied, usually an A. C. E. bandage, or a stockinet bandage called a track bandage. On the tenth day the patient is allowed up in a chair, which is arranged so that he can sit without strain and with the knee flexed to a comfortable degree. On the following day he is given crutches and usually discharged to his home, bearing a little weight. He is instructed to increase the weight-bearing gradually as he feels able, to continue contraction of the quadriceps, and to begin voluntary flexion and extension of the knee while seated high enough to permit the leg to hang freely. The crutches are used for from one to two weeks, depending upon the patient's inclination and the rapidity of the recovery of mobility and of muscle strength. Local heat, massage, and diathermy form no part of the postoperative program, unless there is a complication, and passive movements are never used under any circumstances. The abolition of passive movements is founded on the opinion that they are of no benefit and may often be harmful by causing painful traumatic reactions which retard healing, irritate the soft tissues about the joint, and stimulate reflex spastic inhibitions to active motion.

TABLE I

ANALYSIS OF LESIONS

Type		No. of Cases
Hypertrophy of the infrapatellar fat pad		48
Hypertrophy of the alar ligaments		18
Derangement of the internal meniscus		62
Hypermobility	22	
Rupture	40	
Derangement of the external meniscus		16
Hypermobility	10	
Rupture	6	
Fracture of the cartilage		10
With displacement	8	
Without displacement	2	
Osteochondritis dissecans		12
Rupture of the anterior crucial ligament		4
Fibrosis of the synovia of the anterior crucial ligament		1
Complicating arthritis		7
Proliferative	3	
Degenerative	4	
Total		178

STATISTICAL ANALYSIS

The last consecutive 100 cases which were treated in accordance with this plan have been selected for statistical analysis, and the figures are presented as evidence substantiating the validity and useful applicability of the procedures. Results of essentially the same nature would be shown by similar studies of any other consecutive group of cases in the author's entire series of such arthrotomies; the last 100 were selected because of the accessibility of the records.

Table I shows the lesions which were found in this series of cases.

The practical impossibility of making a positive preoperative differentiation between so many different pathological conditions shows the advantage of an adequate incision so placed as to permit a thorough investigation of the entire joint. This is a strong argument in favor of the routine use of such an incision.

The postoperative complications are listed in Table II.

Naturally the fact that there were no deaths and no infections is a source of much satisfaction. This record is interpreted as a vindication of the program of the whole technique of preoperative preparation, operative procedures (including drainage), and the postoperative care. It is manifestly impossible to ascribe a major rôle to any one element in the composite whole of the factors involved. However, since drainage is the one procedure that is not generally employed by others, it would seem reasonable to suggest that drainage may be a very important factor. Certainly, the absence of any infections indicates quite clearly that drain-

TABLE II

POSTOPERATIVE COMPLICATIONS

	No. of Cases
Death	0
Infection	0
Excessive effusion	7
Adhesions and delayed return of motion	7
Recurrence of symptoms and signs of internal derangement	7
Reoperation	9
Manipulation to restore motion	4

age is not a contributing cause of infection. Of course, it may be that the number of cases of postoperative adhesions with delayed return of motion is larger than that encountered by other surgeons. If so, then perhaps drainage can be held responsible for the 7 per cent. with adhesions. At this risk, however, the author prefers to continue the use of drainage as long as the incidence of infection remains at such a low level.

Table III shows the end results of these operations.

TABLE III

POSTOPERATIVE COURSE AND END RESULTS

Recovery Period:	
Duration of bed treatment	
Average for 90 cases	9 days
Duration of use of crutches	
Average for 88 cases	16 days
Recovery of functional use	
Average for 88 cases	9½ weeks
End Results:	
Full recovery	95 cases
Slight remaining disability	5 cases

TABLE IV

ANALYSIS OF MENISCUS LESIONS

	No. of Lesions	Per Cent.
Internal meniscus	62	79.0
External meniscus	16	21.0
Total	78	100.0

The average duration of bed treatment (only nine days) is less than the author had supposed it to be. It has been customary to plan on ten days in bed, but the period has been shortened in accordance with the effusion and pain and with the patient's wishes. The short period of six-

teen days for the average use of crutches also is surprising. Both of these figures clearly show that the majority of the patients recovered rapidly. The fact that an average of nine and a half weeks was required to restore the knees to functional use was at first disappointing. However, this is not so discouraging in view of the fact that many of the patients were under workmen's compensation insurance, since it seldom is possible to return these patients to their work before the optimum improvement has occurred.

Table IV is presented to show the relative numbers of lesions of the internal and external menisci.

It is hoped that this demonstration that 21 per cent. of all meniscus damage occurred in the external meniscus may help reenforce the contention that the incision must be adequate. Many of the lesions in this series of cases would have been missed if it had not been such a simple matter to enlarge the antero-internal approach and in this way to gain easy access to the outer side of the joint.

In conclusion, the author wishes to emphasize the importance of all of the factors involved in the technique here outlined. It is not possible to show that any single factor is of paramount importance.

MORTALITY IN ORTHOPAEDIC SURGERY

Twenty-Three-Year Report of the New York Orthopaedic Dispensary and Hospital

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Much has been written concerning patients who have been restored to health by operative procedures, but little has been said of those whose death has been hastened or, in certain cases, actually caused by operative interference. Death is so much a part of life, and of medicine, that its inevitableness is perhaps sufficient reason for its lack of study.

In investigating the literature, it is worth while to note that mortality statistics are available upon practically every subject except orthopaedic surgery. There are vital statistics dealing with the death rate in various nations, in various diseases, in sailors and in taxpayers, in infants and in old people, in hot climates and in cold climates, in married males and in unmarried females, and in all branches of surgery except orthopaedic surgery. For that reason, there are no data available with which to enlarge this study of the mortality rate in orthopaedic surgery, or with which to make comparative ratios with other orthopaedic hospitals.

Many arguments have been advanced in explanation of the low death rate in orthopaedic surgery. The principal reasons seem to be two: First, acute emergencies are not as common in orthopaedic surgery as in general surgery; second, since operations are confined chiefly to the extremities, the peritoneal and thoracic cavities are not often entered. However, it should be mentioned that orthopaedic surgery is not without its dangerous operations, in spite of the few fatalities. Witness, for example, the pounding over the heart and lungs in fusing a long thoracic curvature of the spine, with the patient already embarrassed by a huge plaster jacket extending from head to knee. Consider the relationship of the abdominal cavity to lumbar ramisection of the sympathetic nervous system, and the relation of the pleural cavity to costovertebral transversectomy. Think of the close proximity of the spinal cord when the meninges are exposed in fusion of the spine, and, certainly, in laminectomy. Obviously, fusion of the cervical spine for fracture of the neck and removal of hemivertebrae are procedures not to be lightly considered.

Questions of importance to be answered are:

1. In what orthopaedic operations is surgical shock most common?
2. How frequently does embolism occur? With all the work that is performed upon the extremities and the bones, plus the almost constant use of the tourniquet over long periods of operating time, it seems that pulmonary, cerebral, and fat embolism should occur quite often.
3. Is postoperative pneumonia of frequent occurrence? Should it

TABLE I

PRIMARY CAUSES OF DEATH

Cause		No. of Cases
Tuberculosis of the joints		64
Tuberculosis of the spine	33	
Tuberculosis of the hip	20	
Tuberculosis of the knee	3	
Tuberculosis of the spine associated with tuberculosis of the hip	3	
Tuberculosis of the spine associated with tuberculosis of the knee	2	
Tuberculosis of the spine associated with tuberculosis of the sacro-iliac joint and of the shoulder	1	
Tuberculosis of the shoulder	1	
Tuberculosis of the sacro-iliac joint	1	
Poliomyelitis,* acute and chronic		15
Osteomyelitis,** acute and chronic		7
Lateral curvature of the spine		4
Gangrene of the foot		3
Genu valgum		2
Congenital dislocation of the hip		2
Tumor of the spine		2
Unstable fifth lumbar vertebra		2
Spastic paraplegia		2
Fracture		2
Fracture of the femur	1	
Fracture of the spine	1	
Acute suppurative arthritis of the foot		1
Congenital club-foot		1
Acute rheumatic fever		1
Osteitis fibrosa cystica		1
Hemivertebra of the spine		1
Total		110

* Acute, 8 cases; chronic, 7 cases.
** Acute, 5 cases; chronic, 2 cases.

not be expected, particularly in elderly people who suffer long, hard operations, such as those performed on the hip joint, and who are then wrapped in a wet plaster spica, extending from the chest to the toes, placed in bed with no warmth except for a few lights shining on the wet cast, and kept recumbent for many weeks?

The period selected for study was from January 1, 1912 to December 31, 1934. During these twenty-three years there were only 110 deaths out of 20,424 admissions to the hospital. Of the total number of patients admitted, all but 479 were operated upon; the total number of operations was 29,514. These numbers reduced to understandable figures mean that: one patient died out of every 181 operated upon (.0055 per cent.); one patient died out of every 185 admitted to the hospital (.0054 per cent.); and there was one fatality out of every 268 operations performed (.0037 per cent.).

The number of deaths per year ranged between two and six, with the

TABLE II

SECONDARY CAUSES OF DEATH

Cause		No. of Cases
Meningitis		26
Tubercle bacillus	23	
Staphylococcus aureus	1	
Streptococcus viridans	1	
Streptococcus hemolyticus	1	
Surgical shock		16
Generalized tuberculosis and other conditions following localized tuberculosis		15
Miliary tuberculosis	1	
Amyloidosis	2	
Pulmonary tuberculosis	5	
Cachexia	7	
Septicaemia *		11
Bronchopneumonia **		5
Under anaesthesia		4
Embolism		5
Cerebral	2	
Pulmonary	3	
Myocarditis †		4
Hemorrhage ‡		4
Gangrene		3
Surgical infection		2
Accident at operation		2
Empyema		2
Diphtheria		2
Acidosis with persistent vomiting		2
Rupture of tuberculous abscess		2
Into the mediastinum	1	
Into the intestine	1	
Pneumothorax		1
Brain abscess		1
Typhoid fever		1
Measles		1
Syphilis		1
Total		110

* Following surgical infection in 4 cases.
** Following operation in 2 cases.
† Acute, 2 cases; chronic, 2 cases.
‡ Pulmonary in 2 cases.

exception of 1914, when there were no deaths, and 1917, 1918, and 1919, when the deaths per year numbered seven, ten, and eight, respectively. The ages of the patients varied from six months to seventy-three years.

The classification of mortality has been arranged as follows:

1. Primary cause of death or the disease which sent the patient into the hospital, such as tuberculosis of the hip.

2. Secondary cause of death or the contributory cause or causes, such as tuberculous meningitis.

Table I lists the primary causes of mortality.

In considering the secondary or contributing causes, the deaths were reclassified, as shown in Table II.

From this rather uninteresting mass of figures may be drawn much interesting discussion. For instance, why did fifteen deaths occur from poliomyelitis? The answer is that four were due to acute paralysis of the thoracic and abdominal musculature. Bulbar involvement caused another death. For reasons yet unexplained, two patients died of acidosis with persistent vomiting, without operation. Both were girls—one seven and the other two years of age—who, three and eighteen months earlier, had suffered acute poliomyelitis, resulting in weakness of the back, flail lower extremities, and poor abdominal musculature. One intraperitoneal hypodermoclysis was given to the first patient; 500 cubic centimeters of normal saline intraperitoneally, 400 cubic centimeters of glucose intravenously, and rectal taps were given to the other patient. Their conditions did not improve and both patients died on the fifth day. The remaining eight patients died following operative procedures.

This last fact brings up the question as to how long these eight patients were in the hospital for improvement of general condition, through rest and glucose feedings, prior to operation. In all, the length of time was over one week, and the average was eight days. This certainly appears to be sufficient time preoperatively. The causes of these deaths were surgical shock and septicaemia.

Surgical shock produced a total of sixteen deaths. These were analyzed from several angles: (1) type of operation; (2) length of anaesthesia; (3) number of vertebrae operated upon; (4) type of anaesthesia; and (5) period of the year.

1. *Type of operation:* In all except three cases, the operation was performed upon the spine. One of the three operations was a bilateral supracondylar osteotomy for genu valgum in a child of two years; another, the curettage and placing of bone chips in the femur for osteitis fibrosa cystica in a child of seven; and the third, fusion of the hip for tuberculosis in a child of three.

2. *Length of operation:* The time required ranged from forty to sixty-five minutes in the three cases in which the spine was not the site of operation. The time element was greater in the cases in which the spine was operated upon, ranging from one hour and twenty minutes to three hours and thirty-five minutes.

3. *Number of vertebrae operated upon:* The number of vertebrae fused in one stage ranged from five to twelve, and the number involved in laminectomy was four to seven. To-day rarely are more than four vertebrae fused at one stage; this, no doubt, is a great factor in the present decrease in mortality in such cases. It is worth noting, however, that in these cases the operative risk is greatly increased if paraplegia is present.

4. *Type of anaesthesia:* The anaesthesia used was straight ether for children and gas-ether or ethylene for adults. This conforms to normal standards.

5. *Period of the year:* The month of the year seemed to be very important in the causation of surgical shock. In this particular group fourteen of the sixteen deaths occurred in the warm months from May to October. The other two deaths took place during the cold months,—one in December and one in February.

Important in the production of mortality was septicaemia with eleven deaths,—four following surgical infection and seven following incision and drainage for acute or chronic osteomyelitis. The four fatal surgical infections were all in cases of fusion of the spine. Two patients with lateral curvature suffered streptococcus-hemolyticus septicaemia, and two patients with unstable fifth lumbar vertebrae suffered staphylococcus-aureus septicaemia.

Embolus following operation was responsible for five fatalities. Two were cerebral in type and three were pulmonary. One cerebral embolus occurred after exploration of a tuberculous hip, and the other followed extraction of an upper molar tooth in a patient who, eleven years previously, had undergone fusion of the knee for tuberculosis.

The three cases of pulmonary embolism followed, respectively, a subtalar arthrodesis, amputation of a leg, and fusion for lateral curvature. An embolus following the latter operation is difficult to understand, but, apparently, possible. The record stated that the patient's condition was satisfactory until suddenly she coughed up blood and promptly expired.

Acute hemorrhage progressing to death occurred four times. In one case hemorrhage followed incision and drainage of the ilium for osteomyelitis. Nine transfusions were given, three on the day of death. In another case acute hemorrhage appeared from a sinus of a tuberculous spine, upon which no operation had been performed. There were two fatal pulmonary hemorrhages: one occurred nine months after fusion of a tuberculous spine in a patient who was up and about; the other happened four days after exploration of the spine in a patient with carcinoma of the lungs and of the vertebrae.

It was very surprising to find only two deaths due to postoperative bronchopneumonia. One occurred nine days after thoracostomy for empyema in a patient with tuberculosis of the spine; the other took place eleven days after exploration of the spine for sarcoma in a patient aged sixty-two.

Four deaths occurred while the patients were under anaesthesia. Two of these patients were one and three years of age and both had straight ether. Another child was one and one-half years old and the type of anaesthesia was not recorded. The fourth patient was an adult who received ethylene. All died following induction and prior to operative shock. An autopsy on two of the children revealed no enlargement of the thymus gland.

Meningitis was the contributory cause of twenty-six deaths. Two of these were due to accidents associated with the operation. Streptococcus-viridans meningitis occurred twelve days after a spine fusion for tuber-

culosis, at which time pus escaped inadvertently. Staphylococcus-aureus meningitis was present two days after sequestrectomy of the spine had been performed, with accidental opening of the membranes, in a patient who, five months previously, had had a lumbosacral fusion that was followed by staphylococcus-aureus infection. The case of hemolytic-streptococcus meningitis followed a wound infection. Tuberculous meningitis was the cause of the other twenty-three fatalities, and these are to be discussed in a subsequent paper.

SUMMARY

A review of the mortality statistics in orthopaedic surgery at the New York Orthopaedic Dispensary and Hospital, over a period of twenty-three years, reveals the following significant facts:

1. Surgical shock was most common in extensive fusions of the spine for lateral curvature.
2. Embolism was of infrequent occurrence in spite of the almost constant use of the tourniquet over long periods of operating time.
3. Postoperative pneumonia was less frequent than would be expected.
4. Warm months were the most dangerous periods for operative procedures.

CONCLUSIONS

1. No more than five vertebrae should be fused at one stage because of the danger of surgical shock.
2. Second operations at the site of a previous operative infection should be avoided if possible.

SACRARTHROGENETIC TELALGIA

V. A Plan for Treatment

BY HORACE C. PITKIN, M.D., SAN FRANCISCO, CALIFORNIA

This article is the last of a series of five [8, 9]. It is based upon a statistical study of the treatment used in a series of 1,000 patients whose complaints originated in the lower back. It is limited in scope to the treatment of painful affections of the upper sacral joints and of the various supporting tissues that protect the structure and control the function of these joints. The purpose of this article is to present a comprehensive plan for the relief of sacrarthrogenetic pain, but the purpose of the entire series is to stimulate a greater interest in manipulative surgery of the spine.

Manipulative surgery is a therapeutic waif of lowly origin whose infancy and childhood have been shielded from the light of reason by a congenital veil of empiricism and quackery. Consequently, although manipulative surgery somehow has grown to stunted adolescence, the great body of the medical profession rightly has refused to accept a method of treatment that lacks a firm basis in scientific fact. However, our clinical experience indicates that such a basis is available in the recognition of the transitional patterns of scoliosis. In the fourth article of this series, it was demonstrated that all of the patterns of sacrarthrogenetic scoliosis may be reduced to the transitional patterns by gentle manipulation, but that the procedure is irreversible. Thus, although there is much to be learned in regard to the secondary patterns, the transitional patterns simultaneously provide a broad avenue of approach to a clearer conception of the mechanism of scoliosis and a reliable guide in the treatment of the temporarily scoliotic patient.

Any pathological process, except a neurotrophic disturbance, that involves a joint or the supporting mechanism of a joint, produces reflex muscle spasm and a temporary decrease in the mobility of that joint. The protective muscle response elicited by affections of the upper sacral joints is intense and prolonged, because of the fact that stability is paramount in sacrarthral structure and function. Moreover, sacrarthrogenetic muscle spasm results in wide-spread limitation of motion in primarily mobile joints, because the muscles which control the position of the sacrum go far afield for attachments to the spine and to the lower extremities. The steady spasm and the consequent postural defects combine with local pain, telalgia, disturbances of the sympathetic nervous system,* insomnia,

* Axillary hyperhidrosis almost always is present in acute cases. Circulatory changes and dermographia are fairly common. Gastro-intestinal and genito-urinary symptoms are seen infrequently. We have not found in the literature any explanation of these phenomena, but, since they appear, disappear, and reappear regularly and in concert with the local signs and symptoms of sacrarthrogenetic dysfunction, we feel no hesitation in classifying them as associated disturbances.

and fatigue to form a vicious circle which magnifies the disability. In order to focus attention upon the origin of this vicious circle, we have found it convenient to reclassify the pathological processes that commonly affect the upper sacral joints in terms of their ultimate effects upon sacrarthral stability. The following typical headings will serve to illustrate the method:

I. Decreased stability; increased mobility, or destruction:
  A. Physiological relaxation:
    1. Puberty;
    2. Menstruation;
    3. Pregnancy;
    4. Ankylosis of adjacent joint or joints.
  B. Postural strains:
    1. Normal spines;
    2. Congenital defects;
    3. Paralyses;
    4. Bone-deforming diseases.
  C. Traumata:
    1. Sprains of muscles, tendons, ligaments;
    2. Apophyseal subluxations;
    3. Sacro-iliac slips;
    4. Injuries to intervertebral discs;
    5. Fractures (and Kümmell's disease);
    6. Dislocations.
  D. Neurotrophic changes.
  E. Neoplasms.

II. Increased stability; decreased mobility, contractures, or ankylosis:
  A. Traumata:
    1. Sprains;
    2. Subluxations;
    3. Slips;
    4. Fractures;
    5. Hypertrophic arthritis.
  B. Toxic diseases:
    1. Myofascitis;
    2. Neuritis;
    3. Atrophic arthritis.
  C. Suppurative diseases of bones, joints, and supporting structures:
    1. Granulomatous;
    2. Chronic;
    3. Acute.
  D. Diseases of unknown etiology:
    1. Spondylitis deformans.
  E. Surgical arthrodesis.

III. Normal stability; normal mobility:
   A. Traumata:
      1. Sprains;
      2. Fractures.
   B. Surgical:
      1. Release;
      2. Support.

Within the primary divisions of this classification, each condition has been arranged in accordance with its severity, the least effective being placed first. In planning a rational therapeutic program, it should be noted that apophyseal subluxations and sacro-iliac slips may be present in conjunction with any of the affections listed in the first two primary groups of the classification. Therefore, the first therapeutic goal must be the restoration of the normal arthral alignment.* Before one can inaugurate such a plan of treatment, however, he must be able to differentiate between normal and abnormal arthral alignment. The measure of normal sacro-iliac alignment is the absence of a complete pattern of scoliosis, other than one of the two transitional patterns.** The measure of normal sacrolumbar (and other lumbar) vertebral alignment is the roentgenographic record, and particular attention should be directed to the filming and to the interpretation of the oblique views. The classification also tends to emphasize the fact that trauma may affect arthral stability in several ways. Furthermore, clinical experience shows that subluxations and slips are liable to recur, especially those that are found in the classification of decreased stability. Therefore, the second therapeutic goal must be the restoration of the normal arthral stability. When ligaments have been torn, the normal alignment must be maintained until the injured tissues are healed. In the event that cicatrization fails to restore the normal stability, varying degrees of support must be applied in accordance with the degree of the structural deficiency, and again the transitional patterns are valuable guides. Both patterns are produced by unequal, reflex muscle spasm, but the double transitional pattern characteristically

* For example: subluxations commonly are associated with fractures of the spine and, unless manipulative reduction of such fractures is practised, frequently remain unrecognized and unreduced during a long period of immobilization. The injured ligaments heal, and cicatricial contraction restores or increases the normal ligamentous tension in a position that perpetuates the arthral deformity. Finally, when immobilization is discontinued, intractable symptoms develop in relation to the joints that are not in alignment. Thus, one sees many fractured spines that are symptomless, despite gross bony deformity, and others that are the source of a major disability, although the roentgenographic examination gives evidence of perfect healing. From our studies of scoliosis in these contrasting types, we feel that the realignment of articulations is equally as important as the restoration of bony architecture in the determination of the final disability.

** This statement, of course, includes the provisions that there are no structural changes in the vertebral column, and that the lower extremities are equal in length. It is advisable to measure the length from the tip of the greater trochanter to the tip of the fibular malleolus, as a check on the usual measurement from the anterior-superior iliac spine to the tip of the tibial malleolus, since the latter measurement is affected by pelvic torsion. Increasing the inclination of one ilium increases the functional length of that extremity, but decreases the measured length, and *vice versa*.

is found when stability is decreased, and the single transitional pattern characteristically reflects normal or increased stability. Finally, certain pathological processes, notably the suppurative diseases and ankylosing spondylitis, tend to diminish the mobility of the affected joints. Any motion is liable to be painful in such cases, and the final therapeutic goal must be the complete obliteration of all motion.

The plan for treatment that we wish to present is based upon the foregoing principles of realignment, stabilization, and obliteration. Omitting all consideration of general treatment, the plan may be summarized as follows:

I. Realignment:
- A. Relaxation:
  1. Volition;
  2. Local heat (electric pad, lamps, diathermy);
  3. Traction;
  4. Analgesia (local, caudal, general);
  5. Anaesthesia (spinal, general).
- B. Manipulative reduction (fractures, subluxations, slips):
  1. Active;
  2. Passive.

II. Stabilization:
- A. Restoration of symmetrical ligamentous tension:
  1. Freedom from weight-bearing (rest in bed);
  2. Traction;
  3. Physical therapy (postural positions, local heat, manipulation);
  4. Surgical release (individual ligamentotomy, Heyman ligamentolysis, Ober fasciotomy).
- B. Restoration of symmetrical myotonus:
  1. Rest in bed;
  2. Traction;
  3. Physical therapy (postural exercises, massage, sinusoidal current);
  4. Outdoor exercises (walking, swimming, horseback riding).
- C. External support:
  1. Adhesive strapping;
  2. Belt, or girdle;
  3. Brace, or corset;
  4. Plaster (jacket, short spica).
- D. Internal support:
  1. Trans-sacral graft;
  2. Sacrolumbar grafts.

III. Obliteration:
 A. Spontaneous.
 B. Surgical:
  1. Sacro-iliac arthrodesis;
  2. Sacrolumbar facetectomy;
  3. Sacrolumbar arthrodesis.*

The principles of manipulative surgery in dislocations of the spine are well known. The first step is to unlock the articulations by slightly increasing the deformity, and the second step is to reduce the dislocation by traction, lateral bending, and rotation. The principle of manipulative surgery in stable spinal subluxations and stable sacro-iliac slips is identical with the first step in the reduction of the dislocations,—one gently increases the deformity until the articulations unlock. The actual reduction is accomplished by the normal repository forces of the ligaments and muscles that control the joint and usually is accompanied by a springlike snap as the articular surfaces are restored to normal apposition. Very little force is needed in these manipulations. In fact, gentleness is prerequisite to satisfactory results, since the use of force to increase the deformity and to overcome protective muscle spasm necessarily causes additional injury to traumatized ligaments. Furthermore, enthusiastic and poorly conceived manipulations of this type frequently produce subluxations in previously uninjured joints and occasionally cause fractures of articular processes.** For these reasons, the foregoing outline of treatment emphasizes relaxation as the first step in realignment. On the other hand, although unstable subluxations and unstable slips can be unlocked with ease, the depletion of the normal repository forces that allows an unstable position to persist also militates against a spontaneous reduction. Therefore, the principle of manipulative surgery in these cases is similar to the second step in the reduction of the dislocations,—instead of increasing the deformity, one gently opposes it until reduction takes place.

In approximately one-third (31.0 per cent.) of all the patients in this series who received treatment for sacrolumbar subluxations and sacro-iliac slips, reduction was accomplished by gentle manipulation, in the course of the physical examination, before the patient was aware of the examiner's purpose. In a slightly smaller number of cases (28.0 per cent.), the alleviation of spasm, by the local application of heat and by the co-operation of the patient in voluntary relaxation, allowed reduction without the use of undue force. In the remaining cases (41.0 per cent.), the slips were very painful, very stable, or very well protected by a powerful musculature, and other means of obtaining relaxation were employed. After an extensive trial of the various methods noted in the outline, we have come to the conclusion that the relaxation afforded by low

* The recent work of Haas has demonstrated that a definite distinction must be made between intervertebral bone grafts and intervertebral arthrodeses which customarily are grouped together as intervertebral fusions.

** We have seen the roentgenograms that were taken before and after the production of such a fracture.

TABLE I

A Brief Review of the Four Primary Types of Sacro-Iliac Slips

Primary Slip	Stability	Fixed Sacral Tilt	Fixed Iliac Angle
Increased angle.......	1. (Greatest)	Homolateral	Increased
Extension............	2.	Contralateral	Increased
Decreased angle......	3.	Contralateral	Decreased
Flexion..............	4. (Least)	Homolateral	Decreased

spinal anaesthesia (to the crests of the ilia) is ideal in this group. Complete relaxation is limited to the lower extremities and to the pelvis, where relaxation is needed, and the normal reflex protective mechanism is unaffected in the rest of the spine.

Many types of manipulation and many exercises have been devised for the cure of backache, but empiricism has governed the choice of the method with few exceptions. In beginning this study, we collected as many of these methods as we could obtain from all sources and divided them into three groups in accordance with their effect upon the fundamental motions of the spinal and pelvic joints, which are:

1. Flexion;
2. Extension;
3. Rotation and lateral bending:
   a. Spinal;
   b. Sacral, by pelvic torsion (antagonistic iliac motion).

TABLE II

A Summary of the Effects of the Procedure Illustrated in Figures 1 and 2 *

Manipulative Motion	Effect on Superior Joint		Effect on Inferior Joint	
	Sacral Tilt	Iliac Angle	Sacral Tilt	Iliac Angle
Flexion of superior hip and knee............	Homolateral	Decreased		
Extension of inferior hip and knee............			Contralateral	Increased
Rotation of pelvis toward inferior hip.....	Homolateral	Decreased	Contralateral	Increased
Rotation of spine toward superior hip.........				
Distraction of spine and superior ilium........	Contralateral	Decreased	Homolateral	Increased

* The stable slips must be unlocked by increasing the fixed deformity, and the unstable slips are reduced most readily by the motion that corrects the deformity. The statistics presented in the fourth article of this series showed that any type of sacro-iliac slip is reduced in the inferior position more frequently than in the superior position, and the reason becomes obvious when Tables I and II are compared. Conversely, unilateral sacrolumbar subluxations almost invariably are reduced in the superior position in which the articular facets tend to be separated (unlocked) by the rotatory forces and in which the unstable downward subluxations tend to be replaced by the distracting force.

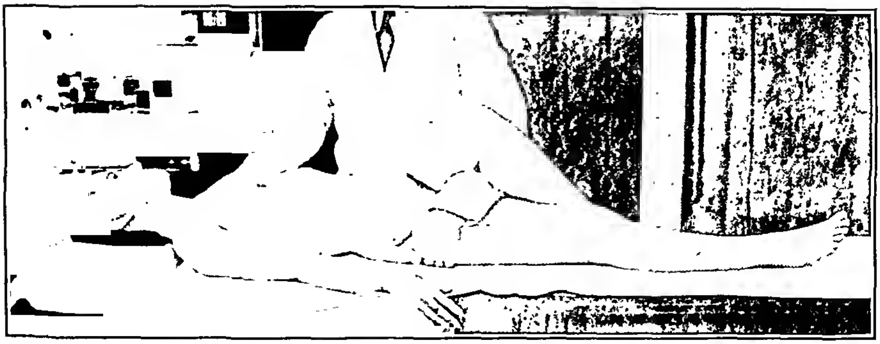

FIG. 1

The first step in the manipulation which the author has found to be most efficient in the reduction of sacro-iliac slips and sacrolumbar subluxations. One of the subject's hips has been flexed and the other has been extended. The operator is about to rotate the subject's pelvis toward the extended hip and simultaneously to draw the inferior hip backward beyond the center of the table (second step).

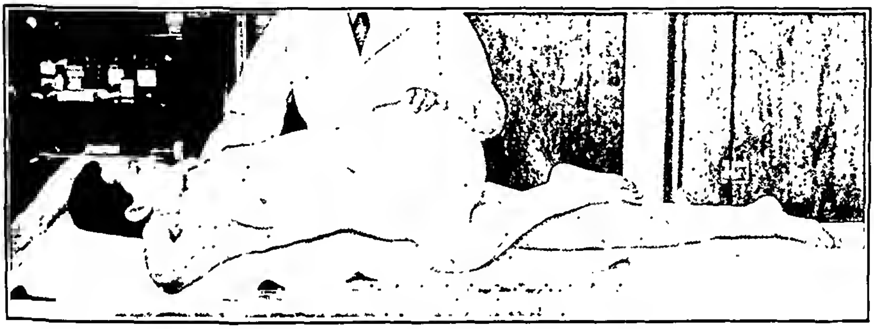

FIG. 2

The third step in the manipulation. (The second step has been completed, and the pelvis has been rotated until the normal limit of spinal rotation has been reached, so that the posterior shoulder is beginning to rise from the table. The fact that the sacrum is strongly tilted toward the superior hip readily can be deduced from the curve of the linea alba, which reflects the left lumbar scoliosis, and from the positions of the anterior superior iliac spines in relation to the iliac crests, which reflect the left pelvic torsion.) The operator presses gently downward and forward upon the superior ilium and upward and backward upon the posterior shoulder, thus adding to the rotatory force a distracting force that tends to reverse the sacral tilt.

At first, we manipulated each spine in all directions and recorded the manoeuver that produced a change in the pattern of the scoliosis. Gradually, we eliminated the methods that were inefficient, that caused pain, or that interfered with voluntary relaxation. Eventually, we discovered from our records that only one of the remaining manoeuvers regularly reduced every variety of sacrarthrogenetic scoliosis to a transitional curve or to an incomplete pattern. (See Figures 1 and 2.) In our experience, this procedure in its active form and supine, alternate, straight-leg lowering are the two most efficient methods of self-manipulation. The final step in this study was to reconstruct the mechanism of the successful method on the basis of the statistical probabilities that were presented in the fourth article of this series. (See Table II.) At the present time, we use almost exclusively (in accordance with

Figure 2 in the fourth article of this series[8]), the type of passive manipulation that is illustrated in Figures 1 and 2, and reserve other methods for the occasional case in which it fails.

Normal ligamentous tension is the first line of defense against luxation, partly because of the inherent strength of the ligamentous structure, but chiefly because of the direct reflex connection between the ligaments and the muscles which protect them. A contracted or irritated ligament sends warning of danger to the supporting muscles too early, and the result is limitation of motion. A ligament that has been stretched or torn sends warning too late to prevent repeated subluxations. In all cases that require a spinal anaesthetic for reduction, and in all cases that show a double transitional curve after reduction, we insist upon a period of rest in bed to provide for the restoration of symmetrical ligamentous tension. At the same time, adhesive traction (ten or fifteen pounds, depending upon the size and the muscular development of the patient) is applied to each lower extremity; this is not removed until the patient has been free from pain for at least forty-eight hours. The patient is not allowed out of bed (except for a brief reexamination) until he has been free from pain without traction for at least forty-eight hours, and until his spine shows an incomplete pattern of scoliosis or a single transitional curve. The use of physical therapy to relieve any contractures that remain after the reduction of ancient sacro-iliac slips needs no explanation. Persistent localized tenderness of a single ligament and characteristic telalgia that is relieved by the injection of procaine into the tender ligament are indications for individual ligamentotomy, provided that no sacrarthral instability is present. We have used this simple procedure in two cases with excellent results.* We also have used the Heyman ligamentolysis in five cases of persistent telalgia that followed surgical stabilization or arthrodesis, and the results were eminently satisfactory, but we have had no experience with the Ober fasciotomy.

If the ligaments are considered as the first line of defense against luxation, the muscles represent all of the other combat divisions in the army of support. Individual muscles that are kept in an almost constant state of reflex spasm for any considerable period of time simply "go stale", and, like a stale athlete, must be given an interval of complete rest and relaxation before training is resumed. The principles of muscle education and of postural training are too well known to need repetition. However, the fact that motoring, golf, and tennis are common causes of recurrent subluxations and slips has not been emphasized sufficiently, and the patient should be denied these activities as long as his spine shows a transitional curve.

* In one of these cases the telalgia persisted after the reduction of an ancient sacro-iliac slip, and the tenderness was localized to the long posterior sacro-iliac ligament at its insertion into the lower surface of the posterior-superior iliac spine. In the other case, the symptoms appeared gradually as late sequelae of an acute, traumatic, ischial bursitis, and were related to the sacrotuberous ligament. Both patients were relieved temporarily by the injection of procaine and were relieved completely by subcutaneous division of the offending ligament under local anaesthesia. The postoperative care was that of a sprain.

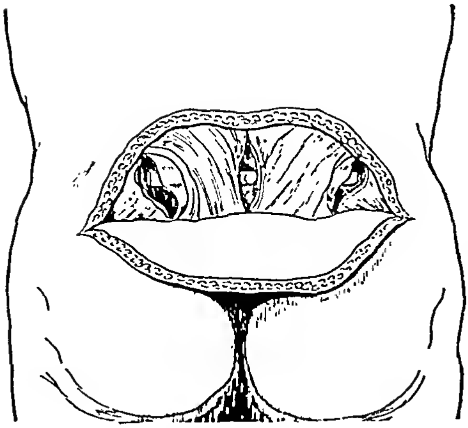

FIG. 3-A

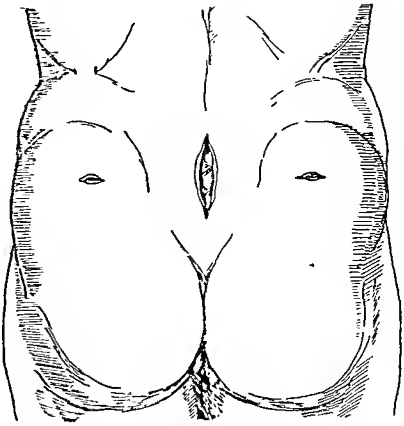

FIG. 3-B

A comparison of Verrall's incision (Fig. 3-A) with those advocated by the author (Fig. 3-B) for implanting the trans-sacral graft.

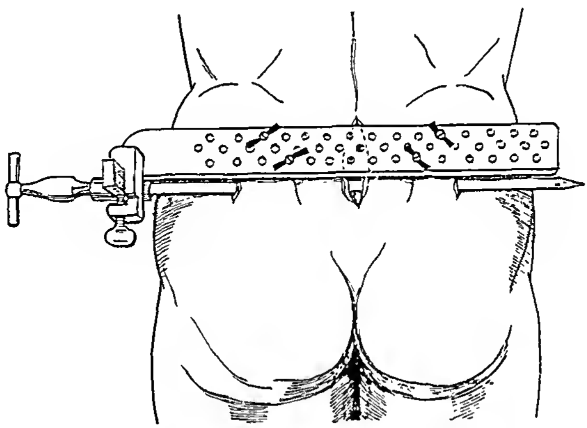

FIG. 4

A simplified technique for implanting trans-sacral grafts. The illustration shows a perforated plate which is subcutaneously fixed to the ilia by four screws and winged nuts and which holds an adjustable drill-guide, together with the special drill and removable drill-handle *in situ*. The butt of the drill is square and is recessed to hold the end of the graft. As the graft is driven through the prepared holes, it drives the drill ahead of it, so that alignment automatically is maintained.

A sprained ligament normally is repaired in from three to six weeks, and rational treatment requires that the ligament be protected from additional injury until it is healed, especially if it is a part of a weight-bearing joint. Adhesive strapping still remains the standard form of external support in the average case of acute sprain, although the local use of procaine analgesia recently has been advocated for the relief of pain and reflex muscle spasm[4]. These generalities may be applied specifically to the upper sacral joints or to an ankle joint with equal logic, and we have found that the gradual disappearance of scoliosis reflects the progress of repair in the deeper joints just as accurately as does the disappearance of swelling and ecchymosis in the ankle. Consequently, the common practice of strapping backs for unreduced sacro-iliac slips appears to be almost as irrational as does the strapping of an unreduced dislocation in the ankle. On the other hand, the common practice of reducing sacro-iliac slips by manipulation without subsequently supporting the injured joints assures the manipulator of a brisk trade in recurrences

Fig. 5-A

Fig. 5-B

Bilateral sacro-iliac relaxation, before (Fig. 5-A) and after (Fig. 5-B) implantation of a trans-sacral graft. Note the restoration of sacral alignment.

and results in a considerable proportion of permanently relaxed joints. Preferences in the matter of external support will not be listed here, since every physician has his favorite appliances which, in his hands, probably are more efficient than any that we might suggest. It is sufficient to note that one may gage the efficiency of a support by observing the manner in which it eliminates transitional scoliosis.

Verrall, in 1923, devised the trans-sacral bone graft and, three years later, reported its use in eight cases. Phelps and Lindsay slightly modified the technique and, in 1929, reported three cases. Ryerson, in 1932, condemned the operation on the basis of one case,* and Massart, in 1932, presented additional technical modifications in his report of two cases. Beginning with an operation in July 1930, we made extensive experimental technical changes in each of our first five cases, but the present procedure (Figs. 3-B and 4) has been used in twenty cases. For lack of space in this article, our experience with the operation must be condensed into the following statements:

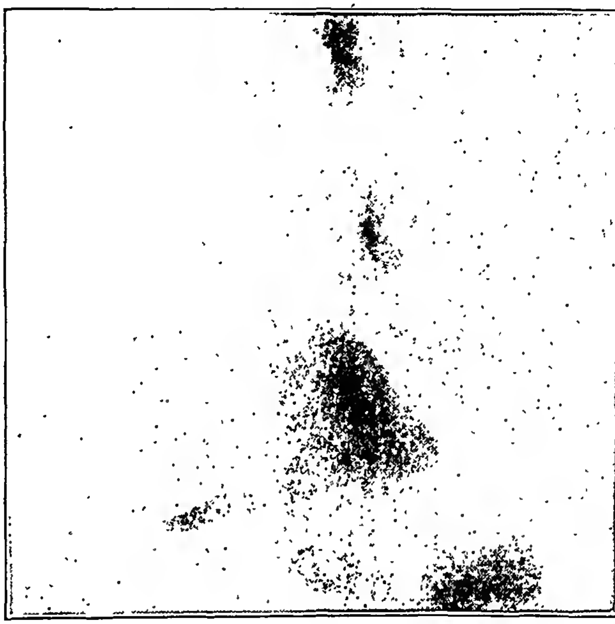

FIG. 5-C

The lateral view shows the position of the graft at the junction of the first and second sacral segments, although the obliquity of the rays in the anteroposterior view casts the shadow of the graft upon the sacrolumbar junction. This graft subsequently became united to the overhanging spinous process of the fifth lumbar vertebra.

1. The trans-sacral graft is a square rod of cortical tibial bone that is extremely stable, because it is driven into round holes in the cancellous bone of both ilia and through the spinous process of the second sacral vertebra. (See Figures 5-B and 5-C.) In less than one year, the graft apparently is replaced by new bone which grows from the three points of bony contact and which, in the roentgenograms, has the soft density of

* Ryerson's reasons for condemning the operation are, in our opinion, its greatest recommendations in properly selected cases. He stated that at reoperation, one year after the implantation of the graft, perfect three-point union was found, but "definite torsion or twisting of the splint had developed", so that "both sacro-iliac joints were freely movable and the graft could be seen to rotate on its long axis in either direction". We have verified these phenomena in five cases, at reoperation, and have kept inclinometric records of the return of iliac mobility in the last twenty cases.

FIG. 6-A

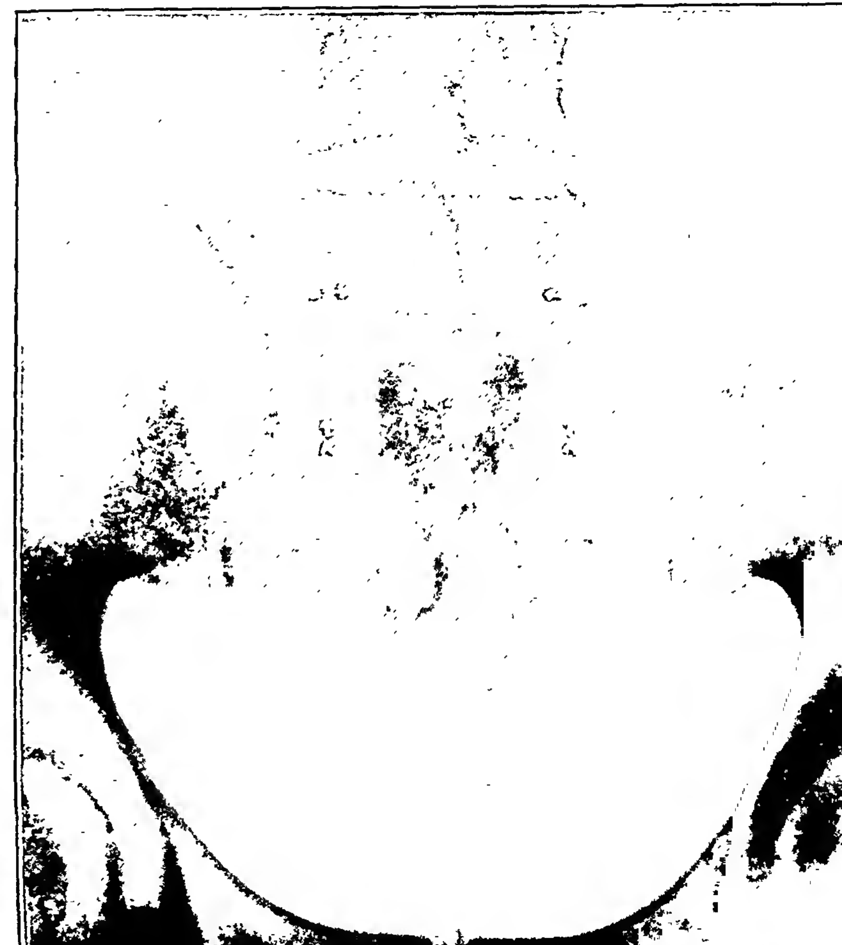

FIG. 6-B

A trans-sacral graft eight months after implantation and immediately after the addition of sacrolumbar uprights (Fig. 6-A). The same case is shown eight months later (Fig. 6-B). The return of sacro-iliac mobility is reflected by the fact that the sacral alignment in the second view is imperfect. Note the formation of the thick, doubly arched bridge (at *A*,*A*) and the replacement of the grafts by cancellous bone (especially at *B*,*B*).

the parent bones. (See Figures 6-A and 6-B.) The resultant doubly arched bridge is larger than the original graft, and the comparative increase in the size of the two arches is in proportion to the degree of relaxation that exists in the corresponding sacro-iliac joints.

2. The operation is unique in bone surgery,—it is not an arthrodesis, and it does not supplant any other operation. The operation immediately restores sacro-iliac stability and supports the torn or relaxed ligaments with a rigid graft that gradually is replaced by flexible bone. As the density of the graft diminishes, torque appears, and the sacro-iliac joints, which at first are completely immobile, gradually regain a normal degree of motion, but remain perfectly stable.

3. The indications for the operation, therefore, are recurrent slips or sprains and uncontrollable sacro-iliac relaxations, especially those that are seen in patients who must return to heavy labor.

4. The contra-indications are a spina bifida of the second sacral segment and any disease or injury that causes a decrease in sacro-iliac mobility.

5. The advan-

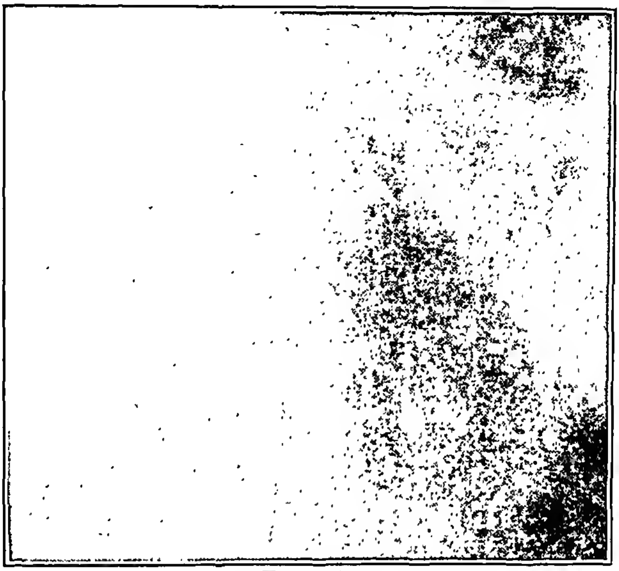

FIG. 7-A

FIG. 7-B

Two lateral views that correspond with the anteroposterior views illustrated in Figs. 6-A and 6-B. Note that the trans-sacral graft and the upright grafts become welded together in a mass of cancellous bone that also fills in the space anterior to the uprights.

Fig. 8-B

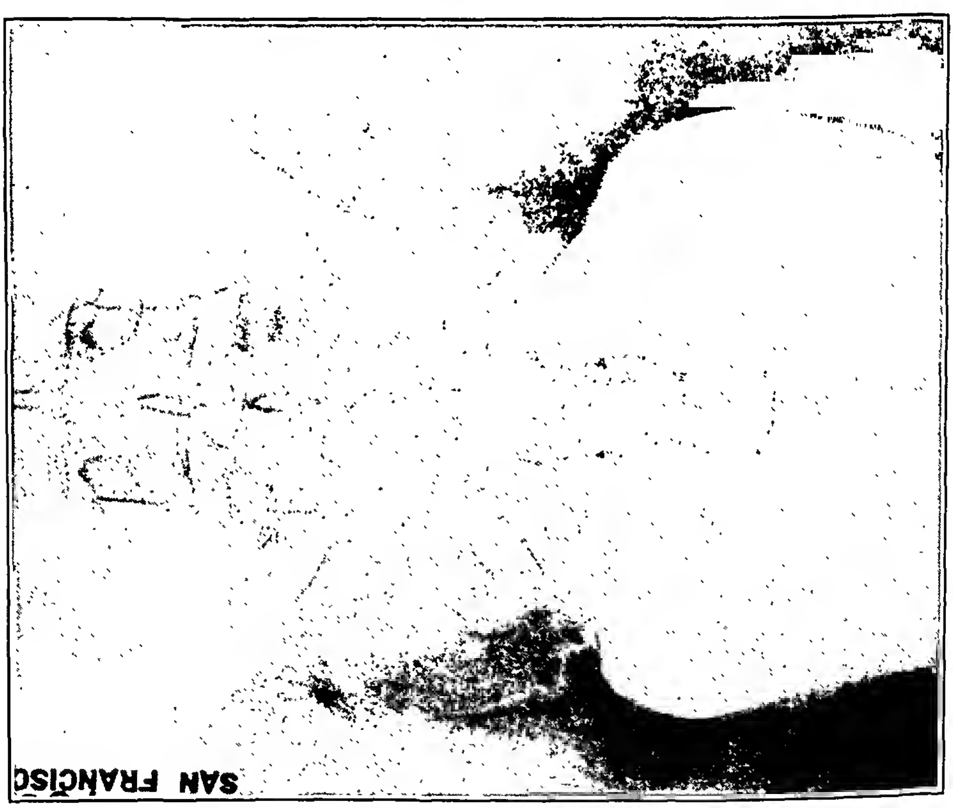

Fig. 8-A

A right sacrolumbar subluxation before (Fig. 8-A) and after (Fig. 8-B) reduction and arthrodesis.

tages of the operation are a sound mechanical and physiological background, an operative speed that is comparable to that of unilateral arthrodesis, and the fact that the trans-sacral bridge forms an ideal foundation for sacrolumbar grafts.

6. The convalescence is remarkably short. No postoperative immobilization is used. The patients are allowed to be out of bed at their own inclination after the third postoperative day. They are permitted to leave the hospital at any time after the removal of the sutures on the tenth postoperative day, and they are allowed to return to work at any time after the eighth postoperative week (provided that they do not show a double transitional scoliosis).

7. The records show that some type of open operation was recommended to 9.5 per cent. of the patients in our series, that one or more operations were performed in 5 per cent., and that the trans-sacral graft was chosen for 2.5 per cent. In other words, 50 per cent. of all cases that came to open operation were considered to be suitable for trans-sacral grafts.

8. Sacrolumbar grafts were added to five (20 per cent.) of the twenty-five trans-sacral grafts. (See Figures 6-A, 6-B, 7-A, and 7-B.) The two upright grafts were driven beneath the trans-sacral graft until they were firmly wedged against the laminae of the fourth or fifth lumbar vertebra (the choice being dependent upon the degree of stability that was required). A posterior covering for the grafts usually was secured by splitting the spinous processes of the affected lumbar vertebrae and reflecting them bilaterally. We consider this to be the most satisfactory type of trisacral stabilization that we have seen. We do not use a cast in these cases, and one of our patients, who left the hospital on the tenth postoperative day and who consistently refused to wear a brace, almost convinced us that immobilization is unnecessary when short, strong grafts are used.

The indications for obliterative surgery are identical with the contra-indications for supportive surgery. In this series, the Smith-Petersen sacro-iliac arthrodesis was applied to twenty-two joints in nineteen patients; one sacrolumbar facetectomy and five modified Hibbs sacrolumbar arthrodeses complete the obliterative group. Uniformly satisfactory results in this type of surgery cannot be expected unless all slips and subluxations are reduced before the arthrodesis is performed. (See Figures 8-A and 8-B)

SUMMARY

The author has classified each of the pathological processes that commonly affect the upper sacral joints in terms of its ultimate effect upon sacrarthral stability and has presented a comprehensive plan for the treatment of these conditions. Each item of the plan has been reviewed in the light of the author's experience in a series of 1,000 patients whose complaints originated in the lower back.

CONCLUSIONS

In the treatment of patients who complain of sacrarthrogenetic telalgia, the restoration of normal sacrarthral alignment by relaxation and by manipulation is the first therapeutic goal. This goal usually has been reached when the patient shows one of the two transitional patterns of sacrarthrogenetic scoliosis. Certain apophyseal subluxations provide exceptions to this rule and must be excluded by roentgenographic study, especially of the oblique views.

The restoration of normal sacrarthral stability, by methods designed to promote symmetrical tension in the ligaments and in the muscles that support the upper sacral joints and by the application of external or internal support, is the second therapeutic goal. When this goal has been reached, the patient usually shows an incomplete pattern of scoliosis.

Whenever alignment and stability are normal, but a condition of decreased mobility is present that is incompatible with painless function, obliteration of the offending joint by arthrodesis is the final therapeutic goal.

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THE USE OF MECHANICAL SUPPORT IN THE TREATMENT OF FOOT AFFECTIONS

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There is scarcely any other phase of orthopaedic surgery about which there is more controversy than the conservative treatment of flat-foot and pes cavus. A great difference of opinion exists concerning the nature of the flat-foot deformity, as well as in regard to the therapy. In general, treatment by support is considered absolutely necessary, but some surgeons [1] oppose the use of any support. The author, himself, has experienced the inadequacy of supports fashioned in the usual shapes. The size, shape, and pliability of the supports, as well as the method of taking the impression, differ in every orthopaedic institution. New types of support are continually being offered, which, however, usually lack anatomical and mechanical perfection.

The purpose of this paper is to state the general opinion of the nature of flat-foot that is held by the majority of orthopaedic surgeons on the Continent, and to describe the support which the author has employed for many years and which differs in many respects from those in general use.

ETIOLOGY OF FLAT-FOOT

Under normal conditions, the foot is held in its plantigrade position by the supinators. Inactivity—the wearing of shoes, the habitual turning outward of the foot, etc.—results in weakness of these supinators, which, due to the weight of the body, causes the heel to sag into pronation. The surface of the calcaneum becomes inclined, and the talus, resting on the calcaneum, is forced by the weight of the body in a plantar, medial, forward direction from its own inclined plane. The caput tali pushes the os naviculare forward, thus resulting in an abnormal mobility (hypermobility) of the tarsus.

The normal architecture of the foot is maintained by the sole muscles. The tarsal and metatarsal bones are relatively more or less mobile when the foot is at rest. Under weight-bearing, they become fixed by the natural contraction of the sole muscles, and, therefore, weakness of these muscles results in laxity of the tarsus. This, in turn, causes the forefoot to bend upward,—an intratarsal reflection which occurs each time the sole is placed on the ground.

The forefoot cannot participate in the pronation of the heel; the counterpressure of the ground forces the first metatarsal upward into a position of relative supination at each step. This pathological torsion causes flattening of the transverse and longitudinal arches, because the head of the first metatarsal is at the same time the frontal and the medial pillar of both arches. The pathological supination of the forefoot is

synchronous with the pathological pronation of the heel, which causes a further laxity of the ligaments of the tarsal joints.

The counterpressure of the ground also results in a bending of the forefoot sideward and outward, producing a position of abduction. This is increased partly by the greater lowering of the higher medial longitudinal arch in comparison with the lateral arch, and partly by the habitual abducted position of the foot, which produces an enlargement on the inner side.

The lowering of the arches of the foot, which previously has been considered the chief factor in flat-foot deformity, is, on the other hand, the result of the pronation of the heel, of the laxity of the tarsus, and of the reflection of the anterior portion of the foot.

In the initial stage, flat-foot is always accompanied by hypermobility of the tarsus, which may exist for several years. Sooner or later, however, there develops a reflex contraction of the muscles (the peronei, the tibialis anterior, and the extensor digitorum longus), accompanied by a retraction of the ligaments,—the spastic flat-foot. The deformation of the bones, which may have commenced during the phase of hypermobility, gradually increases and finally the various deformities of the foot develop.

TREATMENT OF FLAT-FOOT

Since the acquired flat-foot is caused by the weakness of the muscles, the prevention and treatment of this condition must consist in the strengthening of the muscles, particularly of the supinators and of the short muscles of the sole. To accomplish this, gymnastics are necessary, but they can never be done daily over a sufficient length of time. Hence one is compelled to make use of the arch support.

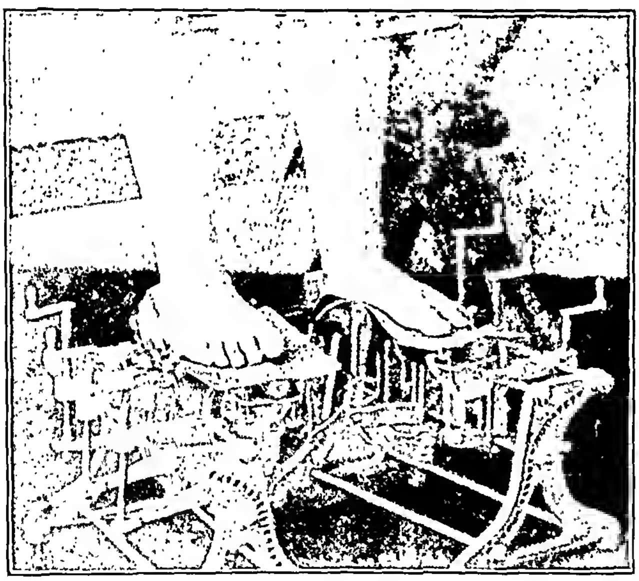


FIG. 1
Modeling apparatus. (*Courtesy of Zeitschrift für orthopädische Chirurgie.*[5])

In view of the factors which are chiefly responsible for flat-foot, the support should have the following objectives:

1. Correction of the pronation of the heel, which originates at the standing phase;

2. Prevention or correction of the reflection of the forefoot in standing and in walking *;

* If marked deformity is present, the support should force the heel into a varus position and the forefoot into plantarflexion and normal torsion.

3. Provision of a rigid support in case of mobile flat-foot.*

In the case of contracted spastic flat-foot, the redressement of which for certain reasons is not indicated, the author recommends tilting shoe heels in addition to the support. The outer side is made of soft rubber, so that the heel tilts toward that side at each step, and the contracted peronei and the retracted ligaments gradually stretch out (the principle of the Thomas heel).

Only in severe and neglected cases does the author resort to redressement under anaesthesia, consisting of plastic stretching of the tendons of the peronei and manual loosening of the tarsal joints without undue force. Then, with the heel in supination and the forefoot in pronation, a plaster bandage is applied, which is worn for four weeks. After the bandage is removed, the patient is not permitted to take even one step without support.

Fig. 2

Planter view of the bones of the foot, showing the transition from the heel part to the forefoot. The dotted lines represent the outlines of the type of support used by the author.

PREPARATION OF MODEL

The plaster impression should be made during normal weight-bearing, and correction should be applied with the patient standing. This cannot be done manually; therefore, a modeling apparatus (Fig. 1) is necessary. This apparatus has been described by the author in previous articles.[4, 5, 6]

The tread-plate of this apparatus consists of three parts: (1) the heel, which may be lifted, lowered, and tilted in order to attain the proper correction of the pronation of the heel; (2) the middle portion, which reconstructs the longitudinal arch; and (3) the anterior portion, which aids in the restoration of the normal torsion of the forefoot and of the vault of the anterior transverse arch.

The patient stands on the modeling apparatus and the necessary correction of the deformity is made. During this process the patient is able to feel and can describe his sensations. After the correction has been accomplished, the patient sits down and on his feet is placed a plaster slab, which reaches to the malleoli and which covers the heel, the sole, the two sides of the foot, and the extended toes. A strip along the dorsal portion of the foot is left uncovered, and the slab is then secured to the foot by a circular bandage of gauze. The patient then steps on the tread-plate, previously set, and awaits the hardening of the plaster. After the removal of the gauze bandage, the negative plaster model may be taken from the foot without being slit. After this negative has been filled with plaster, it then becomes the positive model of the impression from which the size and shape of the support are determined.

* In the case of contraction, the support should have a limited elasticity.

THE FOOT SUPPORT

Three parts of the support should be considered: the heel, the middle, and the forefoot. (See Figure 2.)

Form

The heel part of the support extends from the posterior end of the foot to Chopart's joint. It is more or less trough-shaped, and its purpose is to correct the pronation of the heel. The antivalgus prop, an elevation under the inner side of the heel, is, therefore, an important part of the support. This prop should be applied so that it rests on the solid part of the shoe heel. If the shoe heel is not of the correct height and width *, the best support will not eliminate the valgus deformity.

In order to prevent the foot from sliding off of the oblique plane of the support, in case of severe valgus deformity with hypermobility, a higher outer edge may be applied on the heel part. In order to correct perfectly the tendency to valgus, all of the bones of the tarsus must be sufficiently propped up.

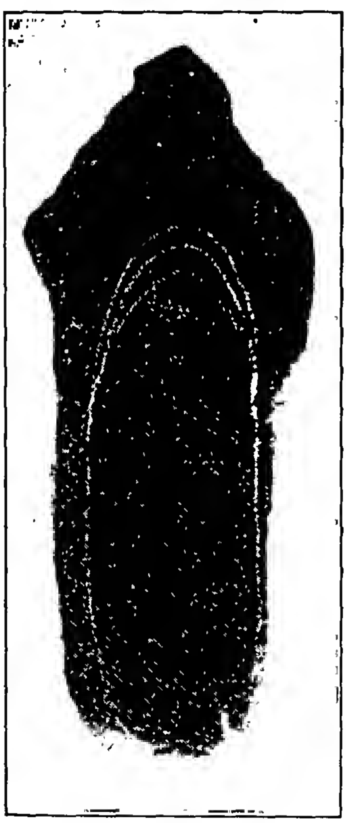


FIG. 3

Model showing outlines of the gradually lengthened supports.

A B

FIG. 4

A: The type of support employed by the author.
B: The too short type of support.

* For men and children, the heel should be two centimeters high and somewhat broadened at the bottom (not conically narrowed). For women, the height of the heel should be three and five-tenths centimeters and the width at the bottom should be at least four and five-tenths centimeters.

The middle portion of the support must be arched longitudinally as well as transversely, to correspond with the cross-vault of the foot. This part of the support is the broadest and contains the summit of the longitudinal arch, which is usually situated below the os naviculare and frequently under the first cuneiform.

The surface of the forefoot part of the support should also be arched both longitudinally and transversely. The convexity, however, should not be interrupted at any point, as is the case with the elevation supports [7, 9] which are so much in vogue. (See Figures 9 and 10.) This type of support has an elevation at its front end with a depression in back of it, which does not correspond to the anatomical structure of the foot and which induces a lowering in the region of the metatarsus. The elevation is usually situated too far back and does not correspond to the normal elevation of the lowered anterior transverse arch.

The height of the vault depends upon the necessity of elevating the anterior transverse arch. If there is lowering of the arch, the support should sustain directly the heads of the middle metatarsals, but there should be no elevation above the surface of the longitudinal vault. In the case of a fixed transverse arch, gradually lengthened supports should be applied. (See Figure 3.)

In case of lowering of the anterior transverse arch, the use of small spherical rubber sponges or pieces of felt beneath the depressed heads is often recommended. However, this procedure is of doubtful value,—as the depressed heads are lifted, their bases are lowered by the same amount and the bending upward (the reflection) of the forefoot is increased. Many surgeons apply on the sole a thick piece of leather, which is fastened transversely to the sole of the shoe in the region corresponding to the metatarsal bones. However, this does not correct the lowering of the central heads, and it increases the reflection in the loosened tarsus, which occurs during walking.

The width of the anterior part of the support may correspond to the width of the forefoot, in which case there must be provision for a convexity

Fig. 5

Showing the torsional and sustaining effect of the author's type of support.

under the middle heads and a concavity under the first and fifth heads. Such a wide support would occupy too much space in the shoe. Therefore, in constructing his supports, the author retains only the middle convex portion, so that the first and fifth heads rest on the sole of the shoe. Thus, a long, narrow form (Fig. 4, *A*) is developed, which forces the forefoot at every step into plantarflexion and normal torsion, thus correcting the flat-foot deformity (Fig. 5).

The center of the anterior end of the support is usually located under the third head. Not infrequently, however, the lowering is the greatest at the second or at the fourth head. In such a case, the highest and foremost point of this portion of the support should be transferred so that it lies under the affected head. Two prongs are provided to secure the position of the support in the shoe. (See Figure 6.)

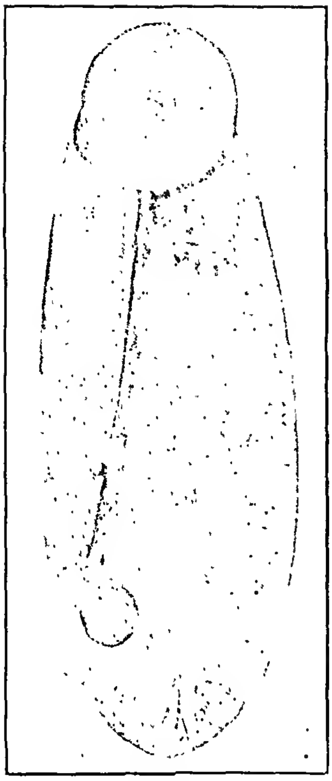


FIG. 6

The author's support without leather covering. At the anterior end is a piece of leather which may be turned and interchanged. The steel rib, placed edgewise, serves as a reenforcement; the posterior end, as an antivalgus prop. To this prop are attached two prongs which pierce the heel of the shoe and prevent displacement of the support.

Length

It is generally recognized that the support must sustain the longitudinal arch. However, the fact is not so well known that the arch must be supported during the entire period that the foot is in contact with the ground. To accomplish this, the support must be sufficiently long (Fig. 7), and this is not true of most of the supports in general use. If the support is too short, it sustains only at the moment of standing. During the period of the contact of the foot with the ground, the counterpressure exerted by the ground loosens the tarsal joints and causes reflection of the forefoot at each step, even though the height of the support may be satisfactory. (See Figure 8.)

The author considers that an adequate arch support should extend at least to the heads of the second, third, and fourth metatarsal bones. Most arch supports extend only to the bases or to the middle of the metatarsal bones. (See Figure 4, *B*.) If there is lowering of the anterior transverse arch, or if, because of Köhler's disease, Deutschländer's disease, Morton's disease, etc., the raising of the head of the middle metatarsal is indicated, the support should be extended to this middle metatarsophalangeal joint. There is no danger of impeding the gait, since walking involves only the contour of the heads of the middle metatarsals.

The best proof that the support is of sufficient length and is in its proper position is obtained by a dorsoplantar roentgenogram taken with the foot in the shoe. (See Figure 10.)

The author attributes the majority of unsatisfactory results obtained by treatment with supports to the fact that the supports have been too short. Although a support is worn, at each step reflection of the forefoot and lowering of the longitudinal arch take place. Moreover, following the use of such a support, lowering of the transverse arch may develop, for the too short support allows a relatively greater dropping of the forefoot, due to the elevation of the middle part of the foot. From his experience the author does not hold tenable Saxl's opinion that the

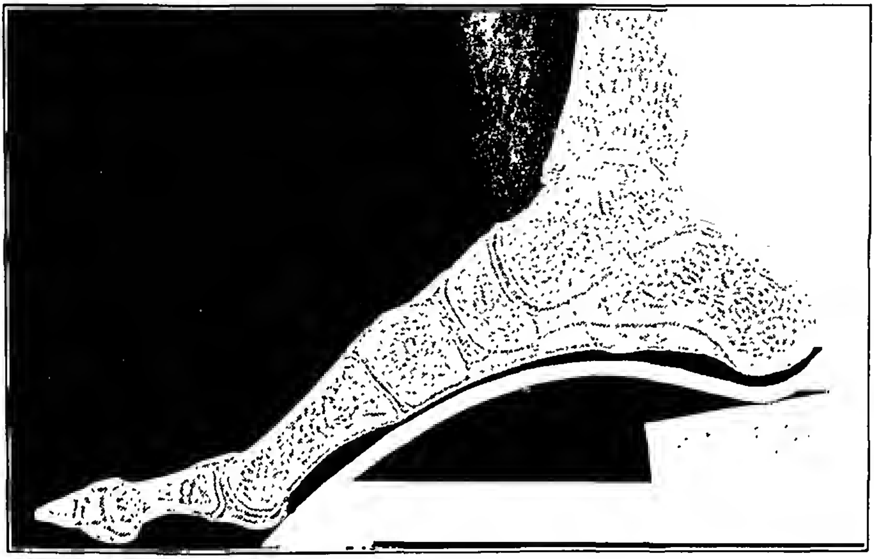


FIG. 7
Showing the effect on the foot during walking of a sufficiently long support.

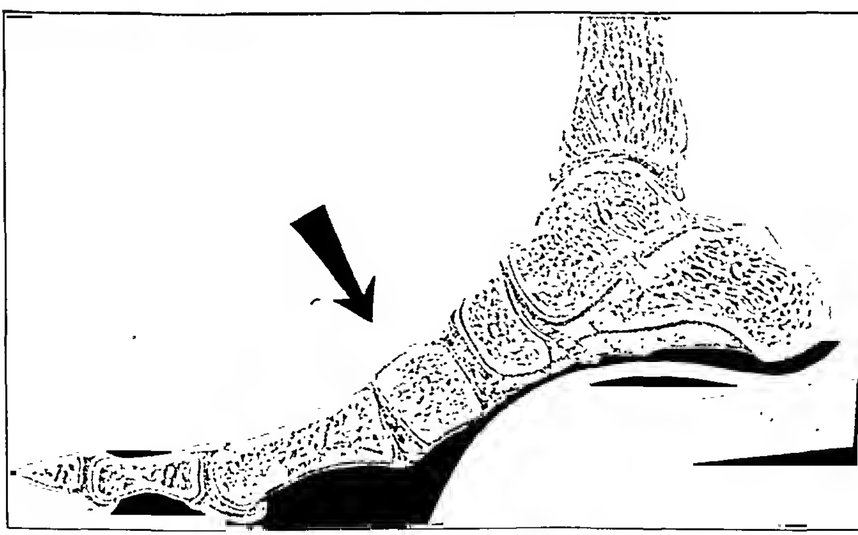
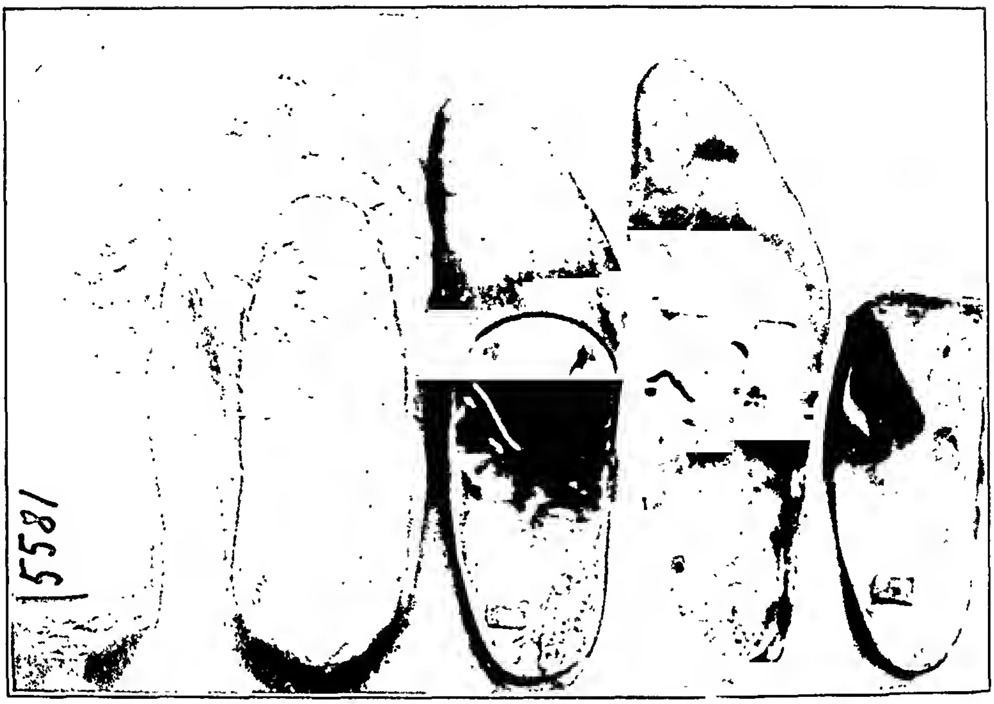


FIG. 8
Showing the effect on the foot during walking of a too short support.



A B C

Fig. 9

A: Model of foot, showing pes cavus with marked lowering of the anterior transverse arch and painful callosities.
B: Positive model, showing outlines of support of the proper length and form.
C: Elevation supports which are too short.

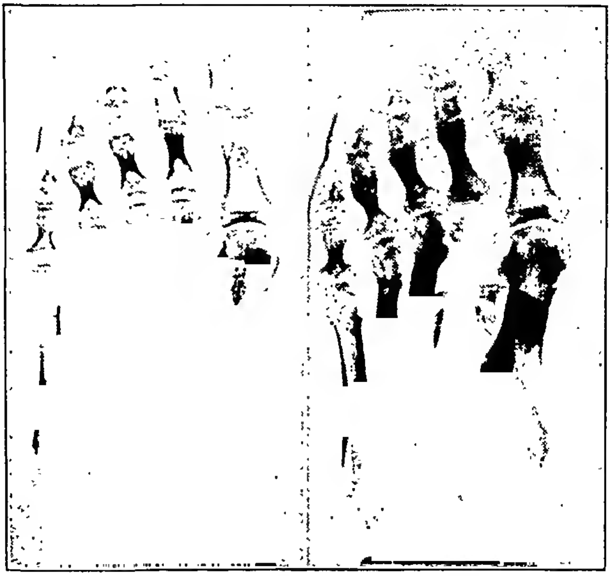
consequent lowering of the anterior transverse arch is caused by the too high arching of the support, for it is difficult to see how a patient could even tolerate a support so constructed.

At the junction of its middle and anterior parts, the support must sustain the bases of all five metatarsal bones. At the foremost part, it must support the diaphyses and the necks of the second, third, and fourth metatarsal bones. The diaphyses and necks of the first and fifth metatarsals should not be supported. According to circumstances, they should be forced to bend in a more or less plantar direction at each step. When the bases of all five metatarsal bones are supported, the plantar-flexion of the first and fifth effects the reconstruction of the arches and of the normal torsion of the forefoot, since the heads of the first and fifth metatarsals are the forward pillars of the longitudinal and transverse arches.

Abduction of the forefoot may also be corrected by the use of this support. At each step the forefoot is forced to deviate slightly in a medial direction. Abduction of the forefoot cannot be corrected by the application of an outer edge at the diaphysis of the fifth metatarsal, for continuous pressure on this point cannot be borne. If the inner edge of the support is raised, pressure is exerted on the inner side of the protruded os naviculare. However desirable pressure may be at this point, the patient cannot endure it. Raising this edge has an additional drawback: the anterior margin prohibits medial deviation,—that is, the desired adduction of the forefoot.

Pliability

For many years the author has maintained that mobile flat-foot requires a rigid support [2, 3], for by this means only can the abnormal play of the lax tarsal joints be eliminated. In the case of contracted flat-foot, the problem to be dealt with is different. The contracted muscles and the atrophied ligaments should be treated gradually by elastic correction,—by a support with an elasticity limited according to the case.



A B

Fig. 10

A: Roentgenogram of foot with the author's support.
B: Roentgenogram of foot with a too short support.

In order to insure the rigidity or to impart the limited elasticity, a steel rib, placed edgewise and following the vault of the support, is riveted at each end to the inferior surface of the metal plate. (See Figure 6.) The mode of application of this rib determines the rigidity or elasticity of the support. If the rib lies tightly along the entire length of the metal plate, the support is rigid and is suitable for the treatment of mobile flat-foot. If between plate and rib there is a distance of from one to five millimeters (greatest in the middle and decreasing toward the ends), the support is elastic and may be used in treating rigid flat-foot. At each step the support has an undulating motion, which gradually mobilizes the contracted tarsal joints. After a few months, the distance between the plate and the rib may be decreased gradually until a rigid support can be used.

The steel rib serves other valuable purposes. Without it, a thick, heavy metal plate would be necessary. Placed edgewise, it reenforces the support. The posterior end of the rib serves as an antivalgus prop. To this prop are attached two prongs which pierce the heel of the shoe and thus prevent a displacement of the support in any direction. The anterior end of the rib is provided at its inferior surface with a round piece of leather which protects the sole of the shoe, and, by increasing the number of these pieces, it is possible to elevate gradually the anterior transverse arch and to increase the torsion of the forefoot.

PES CAVUS

In pes cavus the pressure of the body weight is distributed over a small surface of the heel and the forefoot, causing bursitis, periostitis, and

exostoses of the calcaneum and, with the overloaded and plantarflexed forefoot, a marked lowering of the anterior arch. These conditions, with the callosities which develop on the sole of the forefoot, render walking difficult and painful. Valgus deformity may be associated with pes cavus and occasionally the abnormally high arch of the foot becomes lax.

In the case of pes cavus, the aim of the support is to unweight the overloaded and sensitive parts and to correct gradually the lowering of the anterior transverse arch. This can be accomplished only by a support which has the proper length and form described. (See Figures 9 and 10.)

Operations which seek to correct the cavus deformity by merely lifting the head of the first metatarsal give a poor functional result, because the medial pillar of the anterior transverse arch is lifted from the ground and the lowering of the heads of the middle metatarsals is increased. Resection of the heads of the middle metatarsals destroys the architecture of the entire foot. The paring off of the calcaneal spur is also not indicated, for at the site of operation there remains a sensitive surface of bone and periosteum. If the heel portion of the support is trough-shaped, as described, pain in the calcaneum will cease. An opening in this part of the support is unnecessary.

In the case of a fixed anterior transverse arch with painful callosities, the length of the support should be gradually increased. (See Figure 3.)

SUMMARY

The conservative treatment of flat-foot and of pes cavus is based upon frequent adjustment of the support, gradual correction, and well-chosen gymnastics. Each component of the deformity must be taken care of during the modeling. The noteworthy feature in the construction of the support described is the employment of the dynamics of gait for correction. With this type of support pressure is distributed over the largest possible surface of the sole, but certain portions of the foot are unsupported in order to permit activity of the muscles of the sole,—particularly of the flexor hallucis longus and the peroneus longus. The type of the support always remains the same; it is merely adapted to the individual foot and to the factors which compose the deformity.

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A NEW TYPE OF KNEE HINGE AND CAST FOR THE CORRECTION OF KNEE-FLEXION DEFORMITIES

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It is the purpose of this paper to describe a type of hinge for the correction of flexion deformities of the knee. The hinge is of simple construction: it is easily incorporated into a cast which is used to correct knee-flexion deformities; and, above all, it permits the correction with a minimum amount of trauma to the joint.

An important mechanical factor which should be considered is the fact that the true axis of motion of the knee is at a considerable distance proximal to the articular surface of the femoral condyles, and also the axis lies in a posterior position from the axis of the femoral shaft. This is exemplified in Figure 1. Multiple radii of curvature for the locus of the femoral condyles have been erected on the drawing. It can be seen that

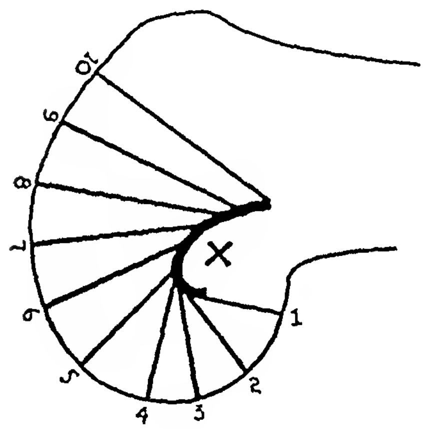

FIG. 1

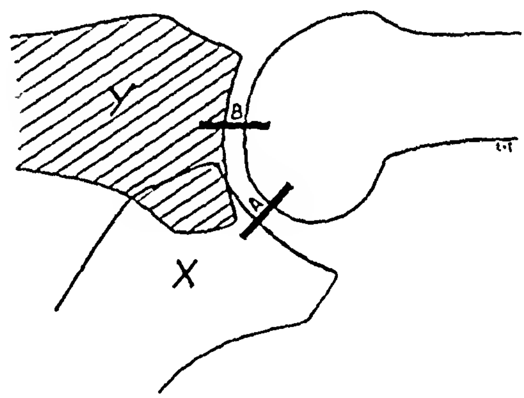

FIG. 2

these form an envelope (X), or the true axis of the knee joint approximates a cycloid, which is situated in a position posterior to the center of the axis of the femur and is also proximal to the articular surface of the condyle.

Another important mechanical factor must be taken into account when a knee-flexion deformity is to be corrected by the use of hinges in a cast. This factor is the constant change of the tibia in a vertical direction as extension is accomplished. The distance which the tibia must travel in an anteroposterior plane depends upon the degree of flexion at the start and, likewise, upon the vertical diameter of the femoral condyles. This principle is illustrated in Figure 2, a lateral view of a knee joint with the tibia and femoral condyles in flexion (X) and in extension (Y). In passing from the flexed position to full extension, the tibia travels in a vertical plane upon the femoral condyles from point A to point B. This

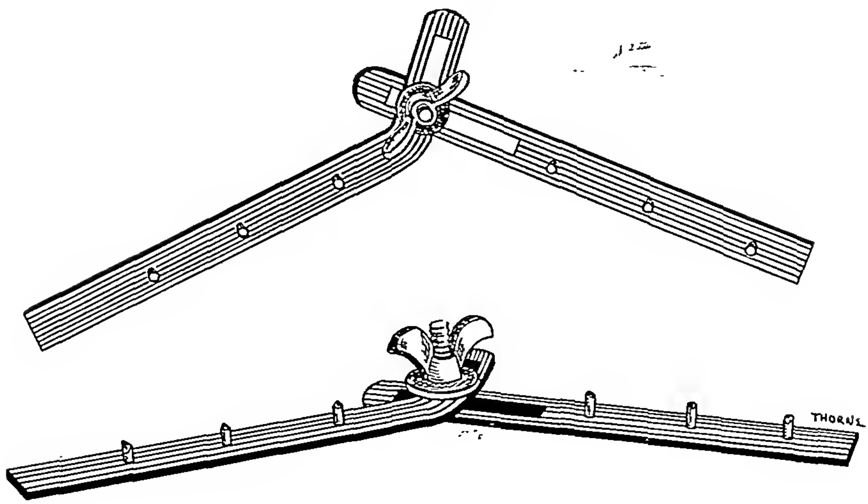

FIG. 3

distance varies with the vertical diameter of the femoral condyles and with the degree of flexion of the knee joint.

Figure 3 shows a type of hinge which is constructed to allow for the two important mechanical principles which have been described. The hinge, which is made of eleven-gage, thirty-per-cent. carbon steel, nine-sixteenths of an inch wide, may be found in almost any workshop. The two arms of the hinge are seven inches in length, and are joined together by an ordinary carriage bolt and a winged nut. The distal end (one and one-half inches) of the proximal arm is bent to an angle of from 45 to 60 degrees. This portion of the proximal arm is also slotted. The angulation and the slotting will permit the distal arm of the hinge to travel anteriorly upon the proximal arm, so that the tibia may also travel anteriorly upon the femoral condyles. This is not allowed when a single jointed hinge is used. The proximal end of the distal arm is also slotted for a distance of one and one-half inches. The slotting of this portion of the hinge permits the tibia to seek, without hindrance, a different radius of curvature upon the femoral condyles with each degree of extension of the knee joint. The two arms of the hinge are joined together through the slots by the carriage bolt and by the winged nut.

When a cast is used to correct a knee-flexion deformity, the two points which receive the greatest amount of pressure are at the lower anterior surface of the thigh and at the upper anterior surface of the lower leg. Even with an excess of padding, the edges of the cast are liable to dig into the leg at these points. Because of the discomfort to the patient, wedging is slow and at times pressure areas develop in these locations. Figure 4 shows the type of cast which is being used at the New York Orthopaedic Dispensary and Hospital to correct flexion deformities of the knee. In applying this cast the knee is padded anteriorly, and a few turns of plaster bandage are wound about the knee. This plaster cuff

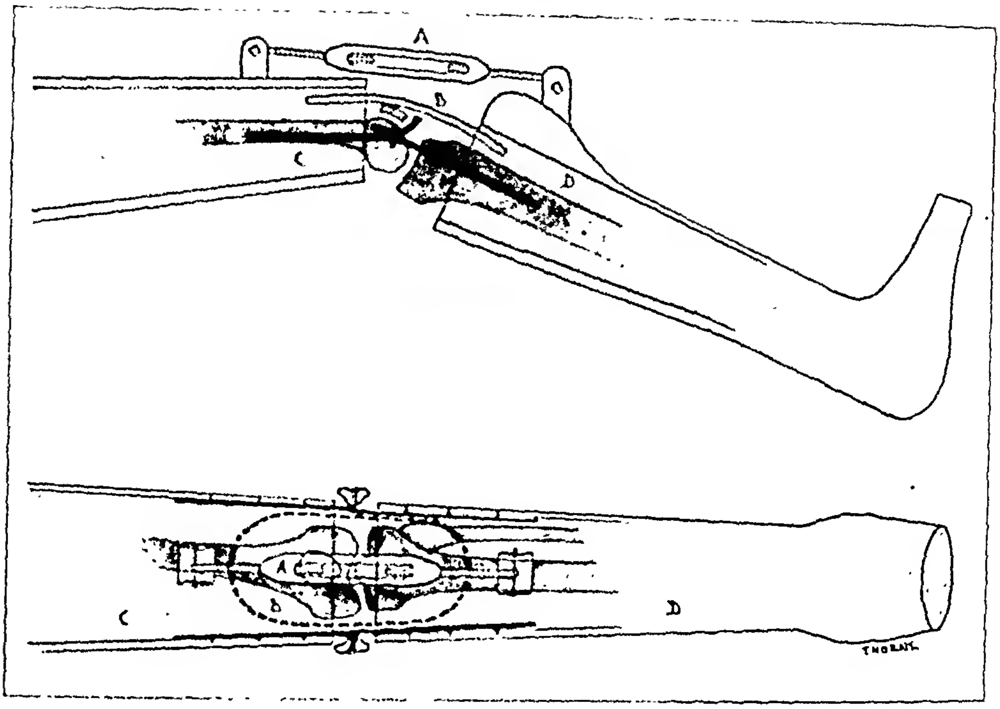

FIG. 4

Cast for correction of flexion deformities of the knee:
A: Turnbuckle *B:* Plaster cap
C: Thigh cast *D:* Lower-leg cast

is then removed by cutting along its posterior surface. From this cuff an anterior knee cap is cut out. This, with the padding, is applied to the knee anteriorly, after the edges of the cuff have been beveled on the surface which comes into contact with the knee. A long leg cast is now applied in two portions, one for the thigh and one for the lower leg and foot. Lateral hinges, which have been described, and either an anterior or a posterior turnbuckle are incorporated into these two portions of the casts. The anterior lower margin of the thigh cast and the anterior upper margin of the lower-leg cast are applied over the plaster knee cap, and are separated from it by a narrow strip of felt. The heel and upper thigh are padded as in all wedging casts.

As the turnbuckle is tightened and the flexion deformity of the knee is corrected, pressure is transmitted by the plaster cap along the entire surface of the knee, of the thigh, and of the lower leg, because the edges of the leg cast slide together upon the outer surface of the cap. As a result of this equal distribution of pressure, there is less pain from localization of pressure, and correction is gained in a shorter period of time.

After suitable correction has been obtained, the winged bolts of the lateral hinges may be tightened with a wrench, the turnbuckle may be removed, and the patient may be sent home. By the elimination of needless changing of casts, correction is constantly maintained.

FRACTURES AND DISLOCATIONS OF THE CERVICAL SPINE

Part I. Fractures *

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INTRODUCTION

To the layman the words "broken neck" are almost synonymous with "death". If perchance the injured person lives, he looks upon the event as a miracle. Unfortunately, many physicians take the same point of view. They look at the injured person, shake their heads, and confide to the family that there is nothing to do but to make him or her comfortable until the end comes. However, if the spinal cord has not been damaged (and it was irreparably damaged in only ten out of thirty-seven cases in this series), the end does not come, and the patient is doomed to live on, usually in discomfort and often with deformity. These sequelae are preventable in the majority of cases.

Knowledge of the fundamentals of fracture treatment is rapidly spreading throughout all communities. That these fundamentals are just as applicable to the cervical region as to other parts of the body is not general knowledge, however. It is the purpose of this paper to emphasize that a fracture of the cervical spine should be "set" just as a fracture elsewhere in the body is set, and that a dislocation of the neck should be reduced just as a dislocation elsewhere is reduced. These conclusions are based upon the treatment given and results obtained in thirty-seven cases of injury to the cervical spine.

With one notable exception, the literature on this subject has been confined almost entirely to the report of isolated cases. This again emphasizes the general feeling of wonderment among our profession, which leads to these reports of successful or surviving examples of treatment. The one exception is the work of Brookes, who has reported a series of over fifty cases. Langworthy reported a series of thirty cases, but his patients were not followed for a long enough time and a diagnosis was not carefully enough considered to make the series statistically valuable. This criticism (particularly as the author is no longer alive to answer it) is in no way meant to detract from the credit that is due him for recognizing and intelligently treating these injuries.

Cases of this sort are not frequently seen, and it takes a long time to accumulate any sizable series. It is hoped that these cases will further emphasize the feasibility of treating these injuries actively and not expectantly.

* Part II, dealing with dislocations, will be published in a subsequent issue of *The Journal.*

GENERAL CONSIDERATIONS *

Symptoms

The first and often the only symptom of a slight fracture of the cervical spine is stiffness of the neck. The patient often does nothing about it until it has persisted for some time. Physical examination usually shows tenderness over the spinous processes of the injured vertebrae. Tenderness laterally at the level of injury is commonly present also. If the injury is more severe, the pain and muscle spasm are more marked, and the patient is apprehensive about moving his head. There is frequently a definite deformity with the head bent forward and at the same time tilted to one side. The significance of this "torticollis" position will be discussed under dislocations. With still severer types of injury there is local hemorrhage and soft-tissue oedema. These may be sufficient to cause peripheral-nerve symptoms, due to compression of the nerve roots as they emerge from the cord, with referred pain and sensory and motor disturbances along the shoulders or down the arms. Occasionally there will be sufficient hemorrhage anterior to the vertebral bodies to cause pressure on the pharynx and difficulty in swallowing. Still more extensive injuries, particularly compression fractures, may so damage the spinal cord as to cause paralysis of any and sometimes all of the extremities and trunk.

Examination

A proper physical examination is essential in order to determine the extent and location of the injury. The most satisfactory position in which to examine the patient is the sitting one. This is not safe, however, if there is evidence of nerve or cord injury. The first thing that should be done, therefore, is to examine the patient neurologically. If there are positive signs pointing to nerve damage, the whole physical examination should be conducted with the patient lying down. This means that examination will be restricted to determining points of tenderness and to testing motion to a very slight degree, and that the ultimate diagnosis will depend upon the roentgenogram. Without evidence of neurological disturbance, the patient may be safely placed in a chair. The only precaution, but an important one, is never to allow any forward flexion of the cervical spine. The danger of permitting forward flexion of the head must be constantly kept in mind during the whole course of diagnosis and treatment.

Preliminary Care

It is not always possible to make an exact diagnosis as soon as the patient comes into the hospital. Roentgenograms must be taken and developed. Their interpretation is often difficult, and frequently it is necessary to take further roentgenograms. In the meantime the patient

* Many of these also apply to dislocations. Complications and operative treatment of these fractures will also be discussed in conjunction with dislocations.

must be cared for until a definite diagnosis can be made and permanent treatment decided upon. The neck is best protected from further injury and irritation by means of a head sling and traction. In order to prevent the traction from being applied in the direction of forward flexion, the patient must be absolutely flat. A Bradford frame with tightly stretched canvas not only keeps the patient flat, but also allows control of the entire spine. A pillow should be placed under the shoulders, thus allowing the head and neck to fall back into a position of hyperextension. (See Figure 1.) In the case of an adult, five or six pounds of traction is sufficient to steady the neck and to overcome muscle spasm.

Diagnosis

The first step in diagnosis is to evaluate the patient's history. There is always the story of trauma. The injury is usually one of moderate to severe violence, and, when a coherent account of the accident can be obtained, we find that the head and neck have been forcibly flexed forward. The history, therefore, tells us little that we do not know already,—namely, there has been an injury to the cervical region.

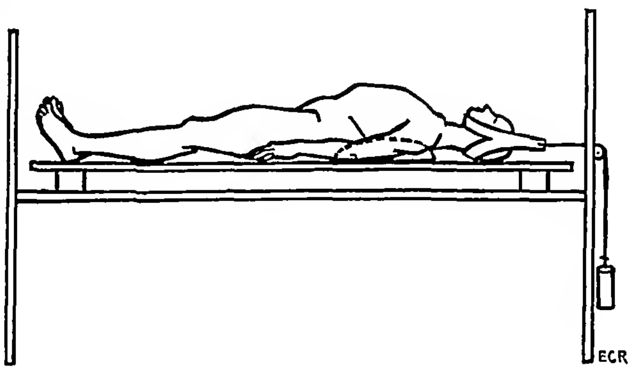

Fig. 1

Position of patient being treated with head traction. Note the pillow under the shoulders and the Bradford frame. Both prevent forward flexion of the neck.

The symptoms enable us to locate that injury more definitely, but they do not help us to differentiate between fracture and dislocation. Pain is an unreliable guide, and, although a fracture is liable to be more painful than a dislocation, yet simple soft-tissue injury or strain may simulate either of the more serious conditions. The presence of neurological disturbances, of course, is a great help in localizing the level of injury and to some extent its severity.

Physical examination is of greater importance than either history or symptoms. Posterior and lateral tenderness are as accurate in localizing the level of injury as are nerve or cord disturbances. Limitation of motions often gives valuable information as to whether we are dealing with a fracture or with a dislocation. In the presence of a fracture, all motions are guarded and painful. A dislocation, on the other hand, often allows certain motions to be unrestricted while others are markedly limited.

The roentgenogram is our most valuable asset and the one on which a final diagnosis is always made. If x-ray equipment is not immediately available, then the injury must be considered as serious until

roentgenograms prove it otherwise. It must be remembered that certain pathological conditions may exist in the cervical spine which may result in the production of a fracture by very slight trauma.

FIG. 2-A

Treatment

Wherever a fracture may occur in the human skeleton an attempt should be made to restore the injured bone to its normal shape and alignment. This is as true of the cervical region as of any other part of the body. Scar tissue and callus form here just as they do in other regions and the sooner reduction is attempted, the better is the chance of success. Except in rare instances reduction is by closed methods and,

FIG. 2-B

FIG. 2-C

Types of plaster jackets and head pieces. Note that the plaster comes well over the occiput and around the forehead and that its weight is carried on the pelvis, not on the shoulders.

FIG. 3-A

FIG. 3-B

Leather collar made from plaster mold. Notice the high occiput and the brow band.

contrary to general belief, is no more dangerous than in other regions of the spine. In twenty-one cases, including both dislocations and fractures, the patients were put in traction and hyperextension for varying lengths of time without any untoward occurrence.

Whatever the type of injury, after reduction has been accomplished the question of fixation arises. In general, complete immobilization is necessary. This can be obtained only by means of a plaster cast. The ordinary Thomas collar which is so frequently applied in these cases is quite inadequate for primary fixation, although it is of value during the late months of treatment.

The plaster cast must extend from the top of the head to the pelvis. If it does not come up over the occiput, the patient can stretch his neck up and out of the chin piece and even turn it slightly from side to side. It is surprising how much ostrichlike motion the human neck is capable of, particularly in children. If the cast does not come low enough to grip the pelvic crests, the weight, which is considerable, will be borne on the shoulders and clavicles, and the patient will be extremely uncomfortable. (See Figures 2-A, 2-B, and 2-C.)

When the time comes to remove the plaster jacket and head piece, the best type of support is a molded leather collar (Figs. 3-A and 3-B). This gives better support than a Thomas collar and is not too sudden a change from the complete plaster immobilization. The transition from complete plaster fixation to entire freedom is further graduated by the use of a Thomas collar for a few weeks before all support is discarded. The importance of regular and gradually increasing active exercises during the periods when the leather and Thomas collars are worn cannot be stressed too strongly. When all support is finally removed, the muscles must have

regained sufficient strength to hold up the head without fatigue. The length of time that the various types of support are worn will be discussed under the various types of neck injuries.

FRACTURE OF THE SPINOUS PROCESS—4 CASES

(Cases 1, 2, 3, and 9)

Probably the simplest type of injury to the cervical spine is a fracture of the spinous process. It can be caused either by direct or by indirect violence, although the former is more common. In two of the four cases in this series (Cases 1 and 2), the patients received direct blows, and in the other two (Cases 3 and 9), the patients fell from considerable heights. Between them these four patients received ten fractures of the spinous processes, suggesting that these lesions are usually multiple. Treatment consists of traction in hyperextension until pain and muscle spasm have disappeared. This is followed by ambulatory fixation either in a molded leather collar or in a Thomas collar, depending on the severity of the injury. Since the elements of the supraspinal ligament which attach to the spinous processes are not powerful, a fixation period of from four to six weeks suffices. The only patient (Case 2) who had symptoms which persisted after healing was complete was one who had received a direct blow on the back of the neck with marked displacement of the fractured fragments of the second to the fifth processes inclusive. This man was not treated at the time of accident and four years later, at the time when this paper was written, he had intermittent symptoms which were relieved by applying head traction overnight at home. In one case (Case 3) non-union without symptoms resulted. It is conceivable that such a case might have persistent symptoms, and, if their severity warranted it, the author would not hesitate to remove the ununited fragment.

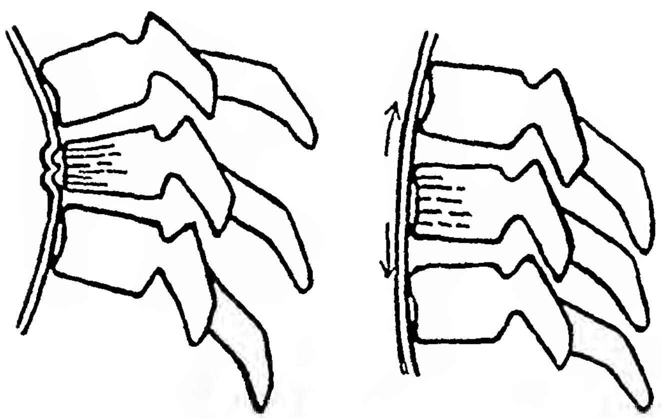

FIG. 4-A FIG. 4-B

Fig. 4-A: Compression fracture of the cervical vertebra. Note how the anterior longitudinal ligament has become slack where it is not attached to the vertebra.

Fig. 4-B: Treatment of the fracture by hyperextension. The anterior longitudinal ligament has been put on a stretch. Attached only at the margins of the vertebral body, it has exerted a distracting force on the compressed bone and has restored the normal contour of the vertebral body.

FRACTURE OF THE ODONTOID—5 CASES

(Cases 4, 5, 6, 33, and 35)

Fracture of the odontoid is a serious injury. When the odontoid is

fractured, and fracture usually takes place at the base, there is nothing to prevent dislocation of the atlas on the axis. This dislocation, in spite of the large neural canal, may seriously or even fatally compress the spinal cord. Furthermore, the odontoid is one of those regions where bony union takes place very slowly and where fibrous union alone is prone to occur. These facts make complete immobilization necessary.

Diagnosis of fracture of the odontoid is difficult. Because a fracture of the odontoid can occur without displacement and give rise to few symptoms, this region should always be x-rayed whenever there is evidence of injury to any part of the cervical spine.

The necessity of complete immobilization has been mentioned. This must be maintained for what at first may seem an inordinately long time. To remove support at an early date, however, is to court disaster, for a sudden movement or strain may shear off the weakly united odontoid and compress the cord. A complete plaster jacket and head piece applied in the manner described should be worn for a period of from two to three months. A molded leather collar should then be worn for a similar period, followed by a Thomas collar for another two months. Fixation during the later stages of treatment may be guided somewhat by roentgenographic examinations, but as a general and safe rule all fixation should not be removed before the end of six months.

At first glance this may seem like overtreatment. No injurious effects result, however, from this long immobilization, and normal motions are regained. On the other hand, inadequate fixation may result in non-union or in fibrous union. It is significant that the one case out of the five in this series which went untreated (Case 5) was the only one in which non-union occurred. All of the fractures of the odontoid were in adults and were the result of severe trauma. Three cases occurred without dislocation, and two were accompanied by a dislocation of the atlas on the axis. In order to allow complete bilateral dislocation to take place in this region, either the odontoid or the transverse ligament of the atlas must give way. Two out of five atlanto-axial dislocations were accompanied by fracture of the odontoid. Although one of these five patients had no odontoid, the relative strength of the ligament and the odontoid must be nearly the same, since each gave way in two instances. (Inquiry into cases treated elsewhere shows that the ligament is somewhat the stronger of the two structures.)

FRACTURE OF THE VERTEBRAL BODY—12 CASES WITH 17 FRACTURES
(Cases 7 to 18 Inclusive)

Under this heading only compression fractures will be considered. In this type the body of the vertebra is crushed between its neighbors, due to forcible flexion of the whole cervical spine. This tends to produce an anterior wedging of the vertebral body similar to that seen more frequently in the lower spine where there is less mobility than in the cervical region. It is not uncommon to see a small chip knocked off of the upper or

lower corner of a body in cases of forward dislocation of one vertebra on another, but in these cases treatment of the dislocation alone suffices.

Since the deformity of a compression fracture is greatest in the anterior portion of the body, hyperextension is necessary to restore normal alignment and contour. (See Figures 4-A and 4-B.) In order to be effective, this should be done as soon after injury as possible. If more than a week is allowed to elapse before treatment is begun, the same results must not be expected as if the patient were immediately cared for. How long a time must elapse before it is hopeless to expect improvement it is difficult to say, depending as it does upon the extent of injury and upon the patient's own power of repair. A slight improvement in bony contour was noted in one patient (Case 14) who had no treatment for three months following injury. Even if it seems impossible to expect any bony change, traction in hyperextension will help to stretch and to mobilize the soft structures, so that often a deformity that is marked in the *roentgenogram* may be invisible on physical inspection. To secure hyperextension, the author has used an inflatable rubber pad which is first placed under the patient in its deflated state. The upper end of the pad comes level with the base of the neck and, when air is pumped in, the patient's head gradually falls back into the hyperextended position. During this time no changes in the traction apparatus are necessary (Figs. 5-A, 5-B, and 5-C) and a pull of from five to eight pounds is sufficient.

When this gradual decompression of the fracture has been accomplished, the question of fixation arises. It is not safe to put on a plaster until the tissues at the site of fracture have reorganized sufficiently to prevent recurrence of the deformity. This time can best be determined by ro-

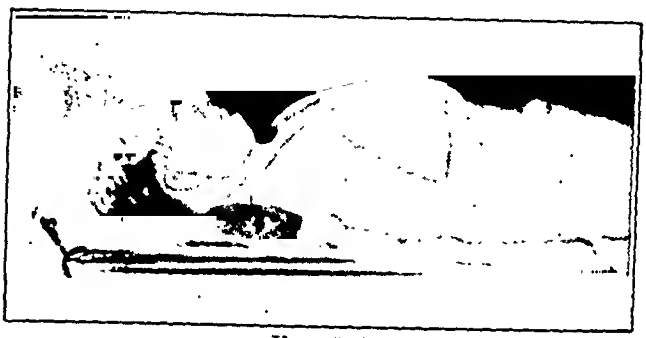

Fig. 5-A

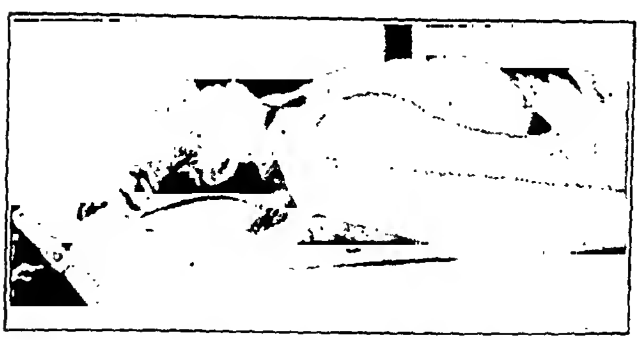

Fig. 5-B

Fig. 5-C

Showing the degree of gradual hyperextension obtainable by means of an inflatable rubber pillow.
Fig. 5-A: Pillow deflated.
Fig. 5-B: Pillow partially inflated.
Fig. 5-C: Pillow fully inflated.

entgenographic examination. When callus formation first begins to show, which is usually in from six to eight weeks, it is safe to apply either a plaster cast or a molded leather support. The latter is preferable, as it is lighter and more comfortable, and can be removed for exercises. Two months later, the support may be removed for washing and shaving provided the patient performs these tasks in a recumbent or semirecumbent position. At these times recumbent exercises can be performed. No exercises should be done in the erect position until three months after injury, at which time the support may be removed daily for this purpose. When the molded leather collar is discarded, a Thomas collar is substituted for it, which is worn for two months. Fixation of some sort is, therefore, maintained over a period of six months. Attempts to dispense with support at an earlier date are liable to result in the recurrence of some or of all of the original deformity, and in addition there is the possibility of late complications. These are due largely to insufficient fixation and will be taken up in more detail later.

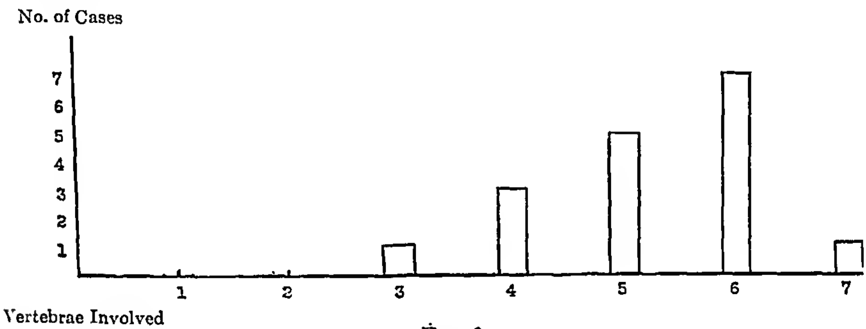

FIG. 6

Diagram showing the vertebrae involved in the cases of compression fracture. The greatest number of fractures occur at the apex of the curve when the neck is flexed.

Compression fracture is more likely to occur in the lower part of the cervical spine than in the upper. In no case in the author's series did the compression fracture involve the first or second vertebra and in only one case was the third vertebra involved. These fractures then became progressively frequent, reaching a peak at the sixth cervical vertebra (Fig. 6).

FRACTURES OF THE LAMINAE, OF THE PEDICLES, AND OF THE ARTICULAR FACETS

These fractures are usually complications of compression fractures of the body or of dislocations. The author believes that some such fracture almost always accompanies a complete dislocation in the lower portion of the cervical spine. Proof of this, however, is very difficult. Roentgenograms are hard to interpret, and a small fracture is easily overlooked. Even when a small fracture is seen, it is often impossible to say just what part of the vertebra is involved. Treatment of the concomitant more serious injury is the surgeon's first regard, and, fortunately, such treatment

is usually sufficient to take care of these lesser injuries also. Once in a while, however, such is not the case. For example, a patient (Case 20) came to the hospital and both physical and roentgenographic examinations showed what appeared to be typical of a complete bilateral dislocation of the fourth vertebra on the fifth. Manipulation was attempted with success only on one side, the other side failing to respond. Later, an operation was performed and the injured region was explored. On one side, the relationships were normal and, on the other, there was found a fracture of the lamina with forward displacement of the entire articulation without any dislocation. A fracture had been recognized roentgenographically before operation, but even reexamination of the roentgenograms after operation failed to show the exact pathology that had been found. Whenever proper treatment instigated early fails to obtain the desired result, the presence of one of these small fractures should be suspected.

CASE REPORTS*

CASE 1. R. B., male, aged forty-five.

December 1930: The patient was struck on the neck by a falling timber and sustained fractures of the spinous processes of the sixth and seventh cervical vertebrae. Sensory changes in the left arm resulted. Treatment consisted of immobilization in a plaster cast for one month, followed by a Thomas collar for one month.

August 1931: Examination showed complete healing without displacement. There were no sensory changes, but some neurasthenic symptoms (pain in the head, etc.) were present. The patient was not working.

November 1931: Figure 7 shows the condition eleven months after injury.

The poor economic result in this case cannot be blamed on the treatment.

CASE 2. C. D., male, twenty-six years of age.

1928: A blow on the neck by a swinging girder caused fracture of the spinous processes of the second, third, fourth, and fifth cervical vertebrae. No treatment was given at this time.

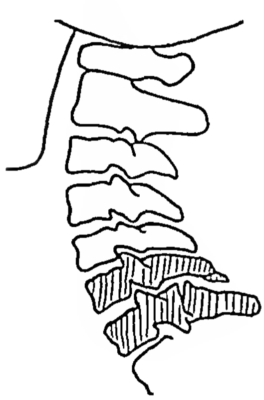

FIG. 7

Case 1. Fracture of the spinous processes of the sixth and seventh cervical vertebrae. Tracing from roentgenogram taken November 8, 1931, eleven months after injury.

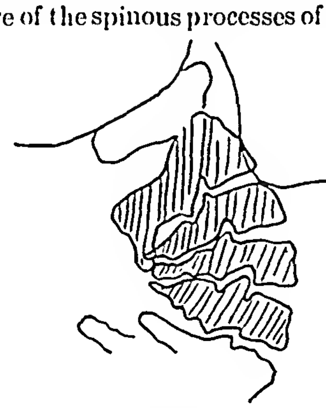

FIG. 8-A

Case 2. March 8, 1932, five years after fracture of the spinous processes of the second, third, fourth, and fifth cervical vertebrae. Neck in hyperextension.

FIG. 8-B

Case 2. March 8, 1932. Neck held straight.

* Some of the cases referred to in the text will be summarized in Part II of this paper, where they more logically belong.

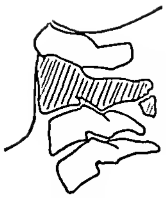

Fig. 9-A
Case 3. December 27, 1932. Fracture of the spinous process of the second cervical vertebra.

1929: The patient began to have pain along the back of the neck, which continued for three years. During this time he suffered a nervous breakdown. His case was studied at two hospitals, but no relief from symptoms was obtained.

1932: The patient entered the hospital and the symptoms were relieved by traction in bed. Figures 8-A and 8-B, tracings from roentgenograms taken on March 8, 1932, show the condition five years after injury.

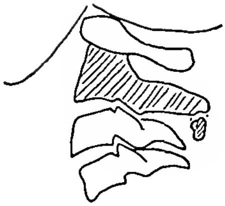

Fig. 9-B
Case 3. December 1, 1933. Eleven months after injury.

The delayed symptoms in this case were due to postural strain and to impinging processes.

Case 3. J. W., male, seventy-nine years old.

December 1932: The patient fell down some stairs and fractured the spinous process of the second cervical vertebra (Fig. 9-A). Treatment consisted of a head brace for two months.

December 1933: Motions were normal, and there were no symptoms. There was no bony union (Fig. 9-B).

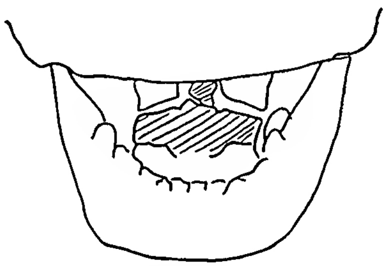

Fig. 10-A
Case 4. May 7, 1930. Fracture of the odontoid.

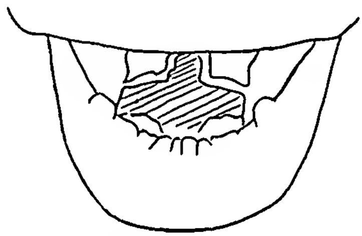

Fig. 10-B
Case 4. May 1, 1931. Firm union one year after injury.

If symptoms had persisted, the fragment would have been removed.

Case 4. F. B., female, twenty-four years of age.

April 1930: The patient was in an automobile accident and sustained a fracture of the odontoid. (See Figure 10-A.) Treatment consisted of immobilization in plaster for three months, followed by a molded leather collar for three months.

May 1931: Roentgenographic examination showed firm union (Fig. 10-B).

November 1933: Motions were normal, and the patient was symptom-free.

Fracture of the odontoid is a serious injury and long fixation is necessary. However, in this series no ill effects resulted from the long period of fixation.

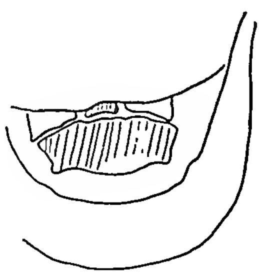

Fig. 11
Case 5. March 29, 1933. Four and one-half years after fracture of the odontoid.

Case 5. C. C., female, aged fifty-five.

August 1928: The patient fell down a flight of stairs and fractured the odontoid and a hip. The injury to the odontoid was not discovered at first, as attention was focussed on the hip. The patient was given a Thomas collar, but

took it off every time that no one was looking. It was discarded entirely on discharge six weeks later.

March 1933: There were no symptoms, and motions were normal. A roentgenogram (Fig. 11) showed non-union.

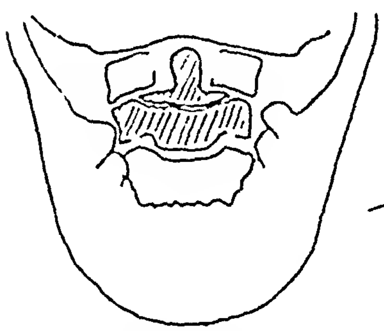

FIG. 12-A FIG. 12-B

Case 6. October 9, 1931. Fracture of the odontoid.

In this case symptoms were obscure and the injury was nearly overlooked. Lack of fixation resulted in non-union.

CASE 6. P. F., male, fifty-five years of age.

October 1931: As the result of an automobile accident, the patient sustained a fracture of the odontoid (Figs. 12-A and 12-B). Traction was applied for one month, and a Thomas collar was worn for two months.

December 1932: Figure 12-C shows the condition thirteen months after the injury. Motion was limited and pain was present. The patient admitted that he had not done the exercises as directed.

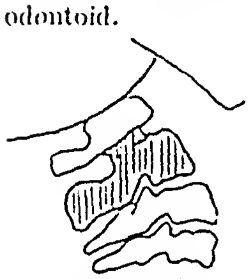

FIG. 12-C

Case 6. Thirteen months after injury.

Fixation was inadequate and union took place because the fracture really involved the body of the vertebra to some extent.

CASE 7. F. C., male, thirty-two years old.

June 16, 1932: The patient dove into shallow water and sustained a fracture of the body of the sixth cervical vertebra, with slight dislocation (Fig. 13). There was complete cord compression at the level of the sixth cervical vertebra. Lumbar puncture gave bloody fluid, normal dynamics.

June 19, 1932: The patient died.

Operation or manipulation was not indicated because of normal dynamics at lumbar puncture.

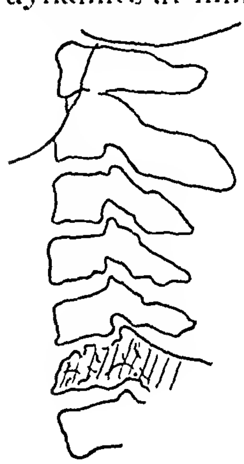

FIG. 13

Case 7. June 18, 1932. Fracture of the body of the sixth cervical vertebra, with slight dislocation.

CASE 8. S. F., male, aged twenty-four years.

November 1933: Due to an automobile accident, the patient received a fracture of the body of the fourth cervical vertebra (Fig. 14-A). Extreme pain and spasm were present. The neurological examination was negative. After reduction (Fig. 14-B), traction was applied for two months. A leather collar was then worn for two months, followed by a Thomas collar for two months.

February 1935: A roentgenogram (Fig. 14-C) showed solid union. Motions were normal. The patient stated that his neck ached when he drove a truck; otherwise he was symptom-free.

Fractures without cord symptoms can be reduced just as can those in the lower regions of the spine.

CASE 9. C. H., male, thirty years of age.

April 1931: The patient fell forty feet, sustaining a fracture of the body of the fourth cervical vertebra and of the spinous processes of the third, fourth, and fifth cervical vertebrae (Fig. 15). There was a complete lesion of the cord at the fourth cervical vertebra. Lumbar puncture showed complete block. No treatment was attempted, and four days later the patient died.

This was a typical fatal case. The patient would probably have died

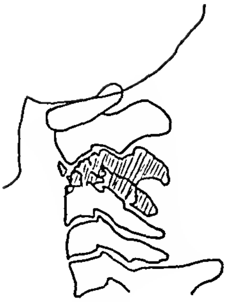

Fig. 14-A
Case 8. November 20, 1933. Fracture of the body of the fourth cervical vertebra.

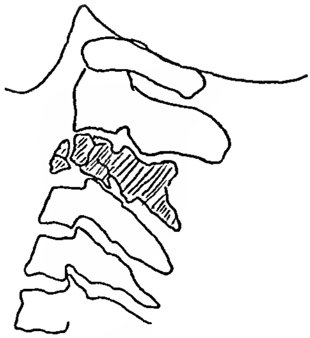

Fig. 14-B
Case 8. November 28, 1933. After reduction.

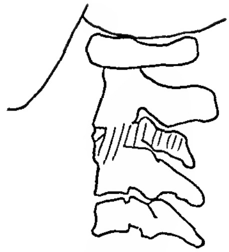

Fig. 14-C
Case 8. February 1, 1935. Solid union fifteen months after injury.

anyway, but, with complete cord block, traction should have been tried.

Case 10. J. K., male, twenty-five years old.

1925: The patient dove in shallow water, resulting in fracture of the bodies of the fifth and sixth cervical vertebrae. There was complete paralysis at first. Lumbar puncture gave bloody fluid. Treatment (at another hospital) consisted of rest, with some improvement in the extremities during the following four months.

1932: The patient entered the hospital where roentgenographic examination (Fig. 16) revealed solid union. The arms were weak, the legs were spastic, and there were sensory changes. Lumbar puncture was negative.

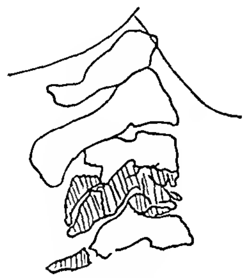

Fig. 15
Case 9. April 29, 1931. Fracture of the body of the fourth cervical vertebra and of the spinous processes of the third, fourth, and fifth cervical vertebrae.

In this case, when the patient was seen by the author, it was too late for anything to be done.

Case 11. T. S., male, aged sixty years.

December 1930: The patient fell off a truck and sustained a fracture of the body of the sixth cervical vertebra and dislocation of the fifth cervical vertebra on the sixth. There was weakness of the arms and of the legs, with reflex changes. Lumbar puncture was negative. Treatment consisted of traction for ten days and immobilization in plaster for one month.

March 1932: Roentgenographic examination (Fig. 17) revealed some loss of bony contour of the sixth cervical vertebra.

April 1932: There was no change in the extremities. Pain in the neck was continuous. Treatment consisted of a leather collar for six months with exercises and physiotherapy.

January 1933: The pain was intermittent and less severe. There was no change in the extremities.

In this case the initial fixation was inadequate. The leather collar should have been applied at the time of the injury, not two years later.

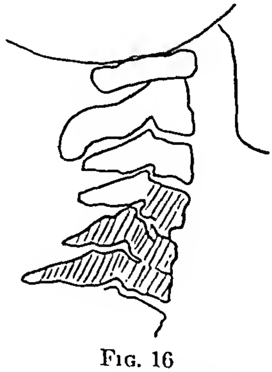

Fig. 16
Case 10. March 9, 1932. Solid union seven years after fracture of the bodies of the fifth and sixth cervical vertebrae.

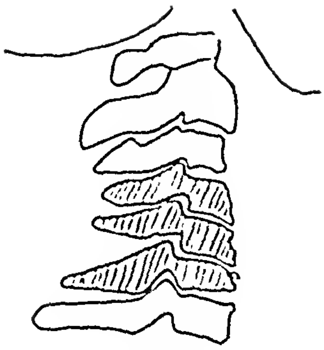

Fig. 17

Case 11. March 11, 1932. Fifteen months after fracture of the body of the sixth cervical vertebra and dislocation of the fifth cervical vertebra on the sixth. There is some loss of bony contour of the sixth cervical vertebra.

Case 12. J. L., male, sixty-four years of age.

September 1933: The patient fell twenty-six feet and fractured the bodies of the sixth and seventh cervical vertebrae. Paralysis of the arms and legs resulted. The patient was given rest at home, with some improvement.

November 1933: On admission to the hospital, the patient exhibited weakness and atrophy of the shoulders and arms. Lumbar puncture was negative. Figure 18-A shows the condition two months after injury. Treatment consisted of traction for two weeks, followed by a leather collar for four months.

April 1934: Figure 18-B shows the condition six months after injury.

November 1934: Roentgenographic examination revealed solid union. The arms were normal, and there were no symptoms. The patient was working on ladders and on roofs.

This is the type of case which is usually fatal.

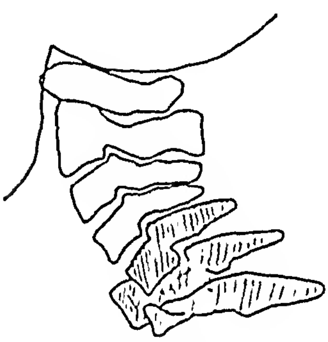

Fig. 18-A

Case 12. November 14, 1933. Two months after fracture of the bodies of the sixth and seventh cervical vertebrae.

Case 13. G. L., male, aged sixteen years.

July 28, 1934: The patient dove in shallow water and fractured the body of the sixth cervical vertebra (Fig. 19-A). Complete compression of the cord resulted. Lumbar puncture gave pressure of 60 with no pulsation. Treatment consisted of hyperextension on a rubber pillow. (See Figure 19-B.)

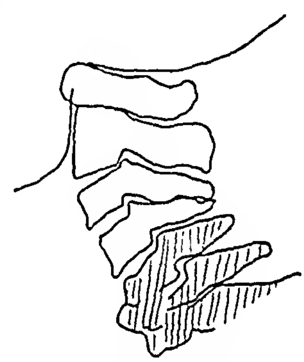

Fig. 18-B

Case 12. April 27, 1934. Six months after injury.

August 5, 1934: Lumbar puncture gave pressure of 110 with pulsation. At this time the patient was put in traction for three months; then plaster shells were applied in order that the patient might be transferred to his home.

May 1935: There was improvement in the condition of the arms, but none in that of the legs.

Operation was not indicated, since traction reduced the fracture and relieved the complete cord block.

Fig. 19-A

Case 13. July 28, 1934. Fracture of the body of the sixth cervical vertebra.

Fig. 19-B

Case 13. July 30, 1934. After traction in hyperextension on pillow.

Case 14. M. M., male, fifteen years old.

July 1929: The patient dove in shallow water and sustained fractures of the bodies of the fourth and fifth cervical verte-

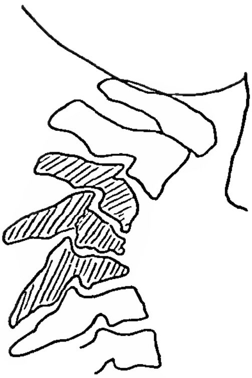

Fig. 20-A

Case 14. November 10, 1929. Three months after fracture of the bodies of the fourth and fifth cervical vertebrae.

brae. As a result the arms were paralyzed for ten days.

November 1929: The condition on admission to the hospital is shown in Figure 20-A. Neurological examination was negative. Treatment consisted of head traction with some improvement. (See Figure 20-B.) A leather collar was worn for six months.

November 1930: Motion was normal and there were no symptoms. Roentgenographic examination (Fig. 20-C) showed that the patient had lost a little of what had been gained.

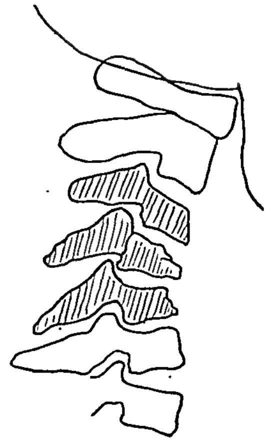

Fig. 20-B

Case 14. November 18, 1929. After head traction.

This case shows that even after three months some improvement is possible.

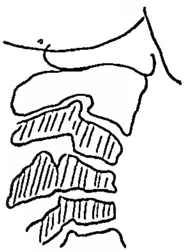

Fig. 20-C

Case 14. November 19, 1930. One year after treatment.

Case 15*. H. R., male, forty-four years of age.

October 1930: The patient fell twenty-five feet and fractured the bodies of the fifth and sixth cervical vertebrae.

November 1930: The patient entered the hospital, and neurological examination was negative. Traction was applied for five weeks, followed by a leather collar for five months. During the latter period the patient was lost track of.

June 1931: There was involvement of the sixth and seventh nerve roots on the left with weakness and sensory changes. All motions were restricted and there was pain on motion.

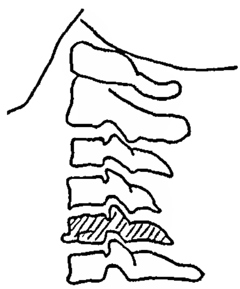

Fig. 21

Case 16. August 14, 1934. Fracture of the body of the fifth cervical vertebra.

This case illustrates lack of after-care; also that nerve complications may arise several months after injury.

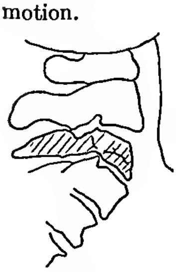

Fig. 22

Case 17. July 28, 1932. Fracture of the body of the third cervical vertebra.

Case 16. C. R., female, aged twelve years.

August 1934: The patient fell out of a tree and sustained a fracture of the body of the fifth cervical vertebra (Fig. 21). There was slight sensory impairment of the fifth and sixth nerves. Traction was applied for two days, followed by a plaster collar for two months.

December 1934: Motion was normal and there were no symptoms. Neurological examination was negative; roentgenographic examination showed no change

* Roentgenograms not available.

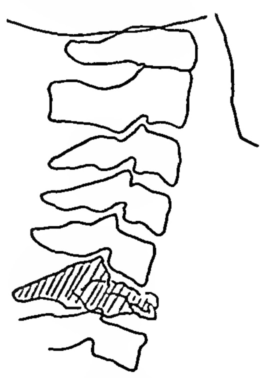

Fig. 23

Case 18. November 20, 1933. Fracture of the body of the sixth cervical vertebra.

In this case the injury was slight and prolonged complete fixation was unnecessary.

CASE 17. S. S., female, aged eighty-six years.
July 1932: The patient fell down-stairs and fractured the body of the third cervical vertebra (Fig. 22). Lumbar puncture gave partial block. The patient died four hours after admission.

CASE 18. M. V., male, twenty-eight years of age.
November 1933: As the result of an automobile accident, the patient sustained a fracture of the body of the sixth cervical vertebra (Fig. 23), followed by complete paralysis. Lumbar puncture gave complete block. Treatment consisted of laminectomy. The cord was found to be hopelessly damaged, and the patient died two days later.

This is a typical fatal case.

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MYOSITIS OSSIFICANS TRAUMATICA

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In treating myositis ossificans traumatica there are three types of cases which must be taken into consideration. These can be divided roughly as follows: (1) those cases in which no treatment is necessary; (2) those in which conservative treatment alone suffices; (3) those in which operative interference is necessary.

The first group, which is probably the most frequent type, is that in which, following minor injuries to the thigh and the buttocks (as in the case of athletes), small, calcified, symptomless areas are discovered in the muscle during examination for other conditions. These are probably the result of contusions or of subperiosteal hemorrhages, and in the organization that follows, by a means not clearly understood, calcification takes place. This type does not need treatment.

The second type presents more extensive calcified areas with definite symptoms and a mass, which is sometimes tender and which occasionally causes a certain amount of disability. Usually during the period of five to twelve months after the appearance of the mass, gradual absorption and ultimate disappearance without symptoms take place. It has been the author's good fortune to follow one of these cases, observing the softening of the mass and the beginning of its disappearance, and to make a pathological examination of the entire mass five months following the injury. An autopsy was obtained after the patient had succumbed to pulmonary tuberculosis.

The third type includes those cases in which the mass is usually located in the region of the joints, disabling the patient by ankylosing or limiting joint motion, and in which, after the proper period of observation, absorption does not occur. While cases of this type are not rare, they are infrequently seen.

The clinical and roentgenographic aspects of several hundred cases of myositis ossificans traumatica have been reported in the literature by Lewis, Finney, Noble, and Campbell. Etiologically the condition has been discussed by some of these same writers, and more notably by Painter and by Rohde. While several theories have been advanced and discussed, none completely accounts for the pathological physiology of the condition. Lewis and Campbell have well reviewed the conservative attitude toward the condition, and Campbell suggests a time limit in waiting for spontaneous regression. However, there remains in the minds of many today the problem of just which cases should be operated upon and which should be treated conservatively. Coley and Ewing described a case in which sarcomatous degeneration followed what was

apparently myositis ossificans, and they emphasized the need of biopsy if doubt of the true nature of the condition exists. Certainly it would be very unwise to delay biopsy of a bone sarcoma on the ground that it might be myositis ossificans. However, the diagnosis in the majority of cases is not difficult if the history is that of trauma or painful bruising, followed by the formation of a stonelike mass with roentgenographic findings as described by Noble.

The apparent frequency of myositis ossificans in the insane has been commented upon.

Following are the descriptions of the courses and pathological findings of cases which are considered to be excellent examples of the operative and non-operative types.

CASE REPORTS

Case 1. F. B., a female, twenty-five years old, who was a manic depressive, fell against a bureau while in a manic state. She was seen promptly by staff members of the sanitarium where she was confined. Roentgenographic examination showed posterior dislocation of the left elbow. This was promptly reduced and the arm was placed in splints at 90 degrees of flexion. Fixation was interrupted by the non-cooperation of the patient, and the splints were finally removed after one month. At that time there was stiffness of the elbow joint, as well as pain on motion.

The patient remained in a depressed state for three months, refusing physiotherapy and holding the arm in about 135 degrees of extension. During this time there was no motion of the left elbow and the attending psychiatrist noticed that there was a consid-

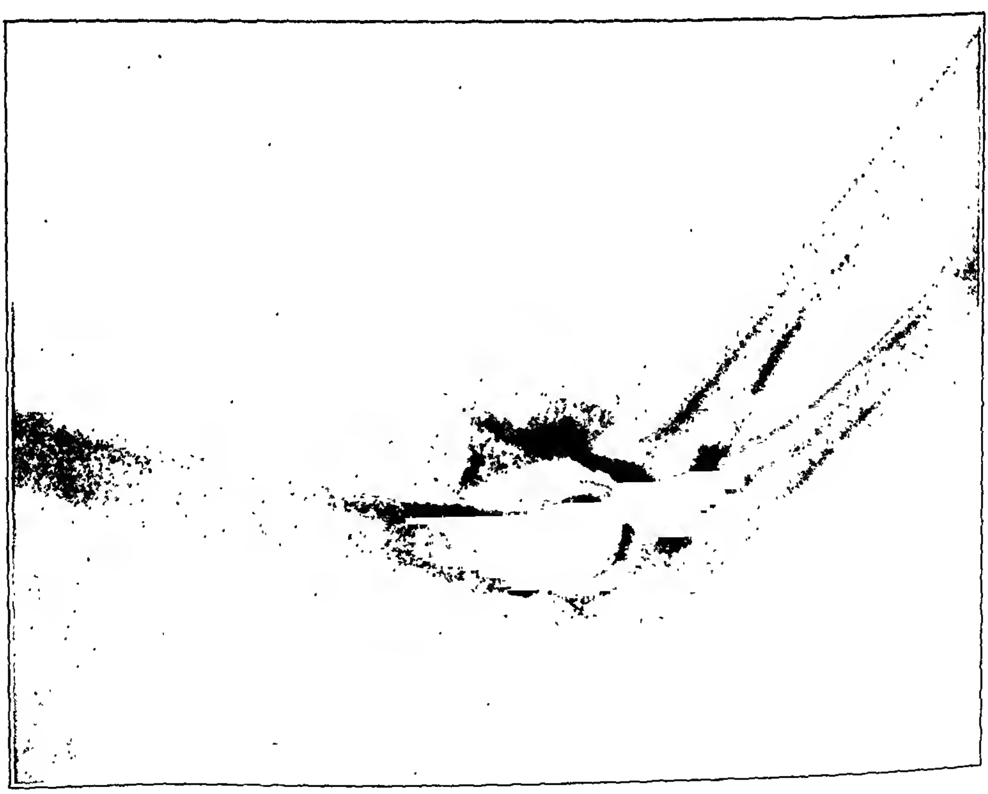

Fig. 1

Preoperative roentgenogram, showing extensive calcification of the brachialis anticus muscle.

crable amount of "stony induration" in the antecubital fossa. Examination showed a completely ankylosed elbow, allowing no flexion, extension, suppination, or pronation. In the antecubital fossa could be felt a sausage-shaped bony mass which, on palpation, was smooth and not tender. No motion of the elbow joint could be elicited with the exertion of great force. The bony landmarks were normal and it was easy to recognize the fact that the dislocation had been reduced. Myositis ossificans of the brachialis anticus muscle was suspected and verified by a roentgenogram (Fig. 1). The mass was observed and x-rayed regularly, but no change in the consistency of the mass or in the density of the shadow could be demonstrated. On account of the ankylosis, some concern was felt about the return of function, and when, after eight months' observation, no signs of regression were present, operation was decided upon.

General physical examination at this time revealed a depressed, but physically normal, young white woman. Positive findings were limited to the left elbow. The temperature was 98.6; the pulse, 80; and respirations, 20. The urine was negative. The blood count showed: hemoglobin, 85 per cent.; red blood cells, 4,600,000; white blood cells, 8,500. Calcium, phosphorus, and phosphatase tests revealed no deviation from the normal. The Wassermann test was negative.

Operation

Under ethylene anaesthesia, an incision was made over the lateral aspect of the upper arm, and continued across the antecubital fossa. The mass was located directly beneath the subcutaneous tissue. Immediately the musculospiral nerve was located, coursing along and apparently included in the substance of the mass. However, it was soon noticed that a few strands of muscle attached to the nerve had not undergone calcification—apparently nature's protection to the nerve itself—which simplified greatly the separation of the nerve from the mass. After the musculospiral nerve had been released, the mass was dissected free from other structures and it became evident that we were dealing with an almost complete ossification of the brachialis anticus muscle, extending from its firm attachment to the lower end of the humerus as far as its attachment on the upper end of the ulna. The humeral end was loosened with the chisel, and during this process the impression was gained that this bone was softer than normal cortical bone, as the sensation was that of cutting into cancellous bone. The mass could now be

Fig. 2

Postoperative roentgenogram of the elbow shown in Fig. 1.

rocked slightly, but it was adherent to the anterior surface of the elbow joint by numerous fibrous bands. These were separated, and finally the entire ossified muscle was removed by chiseling it free from its ulnar attachment. The vessels were ligated and the wound was closed in layers. A cast was applied with the arm in a position of more than right-angle flexion. The cast was removed at the end of one month, following which physiotherapy, consisting of baking, massage, and passive and active motion, was begun.

Improvement was slow, but at the time of this report, five months after operation, there was slight limitation of full extension and of flexion, but practically no limitation of pronation and of suppination. The patient used the arm with ease and satisfaction for all her household duties, and had no pain. Postoperative roentgenograms (Fig. 2) showed no tendency to reappearance of ossification. Mentally the patient was normal.

Pathological Examination

Sections showed areas of degenerating muscle fibers with a considerable amount of fibrosis, osteoid tissue in which there were beginning lacunae, cartilaginous appearing cells, and, in places, what seemed to be ill-formed bone marrow. There were no giant cells, osteoclasts, or true osteoblasts. The resemblance to cancellous bone was striking. No evidences of regression were present in the slides (Figs. 3 and 4).

CASE 2. G. C., a male, thirty-six years of age, fell on the buttocks in November 1935. The injury was considered to be a bruise and, because of its minor character, the patient did not think it necessary to consult a physician. One month later, the swelling had persisted and, although no longer discolored, it had "become hard". At this time the patient consulted a physician, who told him that the swelling would disappear and advised him to apply heat. Upon failure of the swelling to disappear, six months after the injury, the patient again sought the advice of a physician and was seen by the author.

Examination revealed that the induration extended along the fibers of the gluteal muscle, that it was stony hard, and that it moved *en masse* when manipulated. Roentgenographic examination bore out the contention that we were dealing with myositis

FIG. 3

Case 1. Section showing degenerated muscle fibers, bone formation, and fibrosis.

ossificans. While the patient was under observation for this condition, routine physical examination disclosed active bilateral pulmonary tuberculosis, and clinicians agreed that the lesion would be fatal. During the patient's stay in the isolation pavilion, the

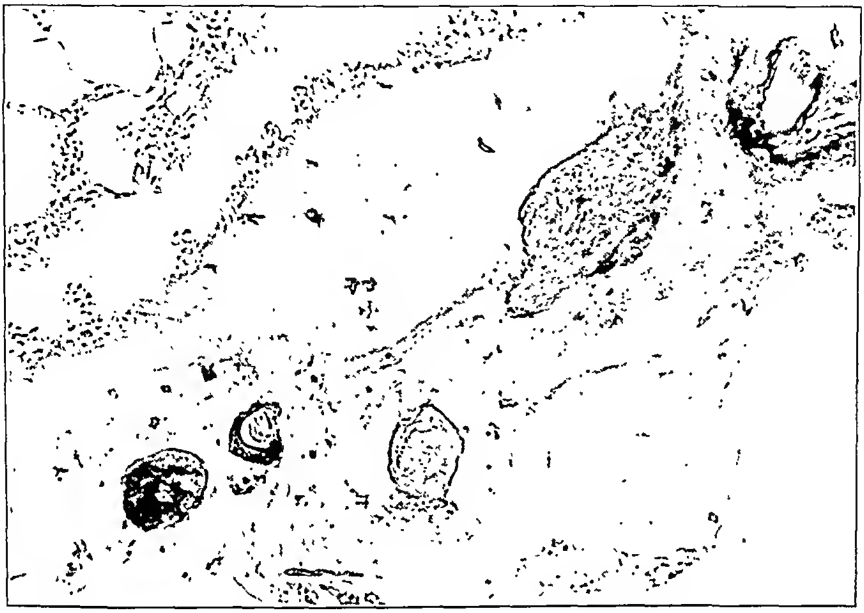

FIG. 4

Case 1. Section showing bone, lacunae, and fibrosis. Note the absence of osteoclasts and osteoblasts.

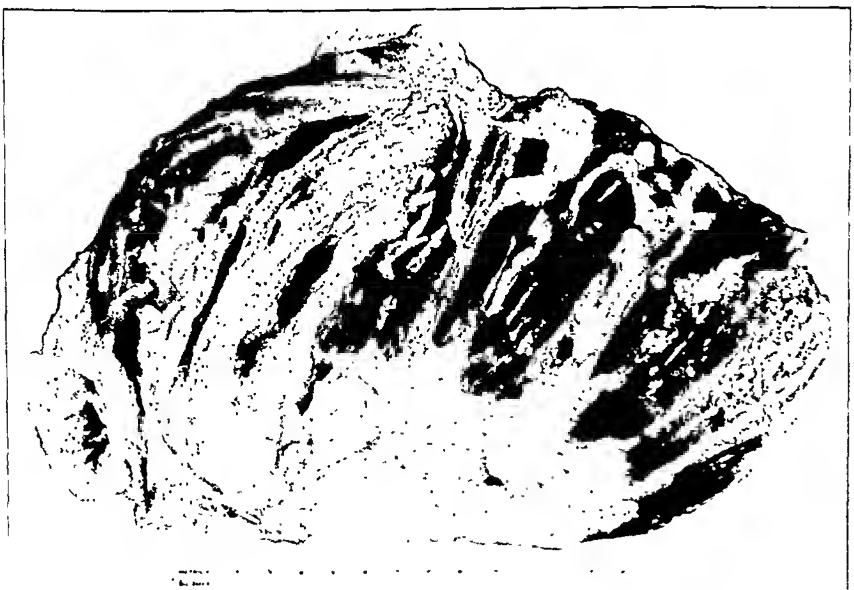

FIG. 5

Case 2. Gross specimen.

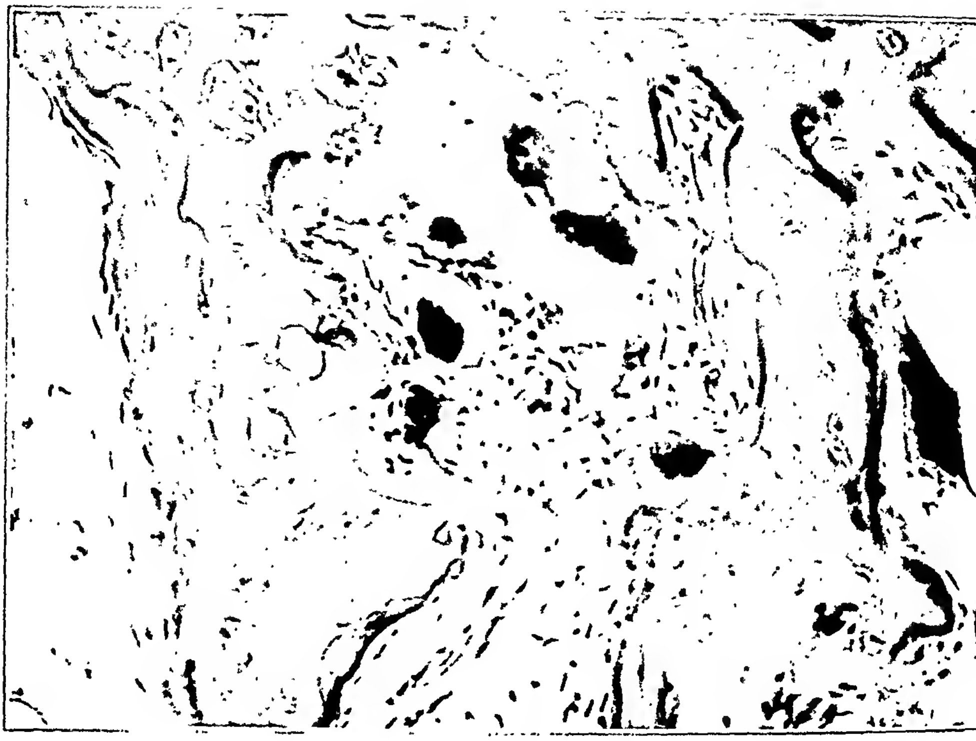

FIG. 6

Case 2. Section showing bone, lacunae, fibrosis, numerous giant osteoclastic cells, and cells resembling osteoblasts.

gluteal lesion was observed and two months after admission it was noted that the mass was smaller in size and softer in consistency; three weeks later it was still softer in consistency and gradually becoming smaller. This process of diminution and absorption was observed for five months, at the end of which time the patient succumbed to tuberculosis.

An autopsy was performed and the entire gluteal group was removed *en masse* (Fig. 5). Inspection of the mass, in which only a part of the muscle was involved, showed a striking resemblance to the exposed vertebrae during laminectomy. The bone had the appearance of cancellous bone and, when cut, resembled that kind of structure.

Pathological Examination

A very different picture was seen from that of the first case described. There was degeneration of muscle, showing fibrous and osteoid tissue with large nuclei, cartilaginous cells, and evidence of an attempt at bone-marrow formation. In all the sections, however, there were numerous giant cells and osteoclastic cells. A few osteoblastic cells were seen. The numerous osteoclastic cells were, of course, evidence of bone destruction. Since they were predominant over the osteoblasts, the pathological picture was believed to be one of absorption (Fig. 6).

SUMMARY

In the treatment of the condition known as myositis ossificans traumatica, the necessity of operation in cases of non-absorption and disability is stressed.

Comparison of the pathological findings showed a predominant number of giant or osteoclastic cells in the case in which absorption took place, while not one of these cells was present in the case demanding operation. These pathological pictures clearly parallel the clinical observations.

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EFFECT OF SYMPATHECTOMY ON THE LEG LENGTH IN CORTICAL RIGIDITY

BY STEELE F. STEWART, M.D., LOS ANGELES, CALIFORNIA

The work of Harris has drawn attention to the possible effect of sympathectomy in connection with the lengthening of short limbs in infantile paralysis.

In a very large series of sympathectomies done to correct the cortical rigidity of infancy, it has been possible to follow six patients upon whom sympathectomy was performed on only one side.

CASE 1. M. P., twelve years of age, with right brachio-skelic rigidity. In 1929, right cervical and lumbar sympathectomies were performed. No shortening of the leg was observed at the time of the operation. In July 1936, the right leg was one-half an inch longer than the left.

CASE 2. V. S., nine years of age, with right skelic rigidity. In 1930 a right lumbar sympathectomy was done. There was no observable difference in the length of the legs at the time of the operation or in July 1936.

CASE 3. B. L. S., four years of age, with left brachio-skelic rigidity. In 1930, left cervical and lumbar sympathectomies were performed. There was no observable difference in the length of the legs at the time of the operation or in 1936.

CASE 4. B. R., eleven years of age, with right cranio-brachio-skelic rigidity. In 1928, right cervical and lumbar sympathectomies were done. No observable difference in the length of the legs was present at the time of the operation or in 1936.

CASE 5. H. B., three years of age, with right brachio-skelic rigidity. In 1929, right cervical and lumbar sympathectomies were performed. No difference in the length of the legs was noted at the time of the operation. In 1936, the right leg was one-half an inch longer than the left.

CASE 6. A. S., six years of age, with left brachio-skelic rigidity. In 1927, left cervical and lumbar sympathectomies were done. No difference in the length of the legs was observed at the time of the operation or in July 1936.

In this fairly short series of cases a change in leg length occurred in only two patients and this to a relatively minor degree. Therefore, sympathectomy cannot be said to have much, if any, effect on the length of the extremities in cases of cortical rigidity.

AN UNUSUAL CASE OF POST-TRAUMATIC DECALCIFICATION OF THE BONES OF THE FOOT

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The following case is one in which an unexpected and unusual degree of decalcification of the bones of the foot followed a moderately severe, localized, and comparatively common type of injury.

CASE REPORT

June 1926

A strong, healthy, active girl, aged fourteen years, of healthy parentage, and presenting no neurosis, tripped over a rope and came down heavily on the toes of the left foot. There was immediate pain of a severe and disabling character. On examination, the injury was found to be localized. Marked swelling and tenderness were limited to the tarsus and the metatarsus, and there was a strikingly well-defined line of bruising from the bases of the toes to the level of the midtarsal joint. There was no pain or constitutional disturbance.

After three weeks' rest, all signs of injury had disappeared and there was no disability.

April 1927

The patient complained of slight discomfort, thought to be due to "flat-foot". No abnormality was detected on roentgenographic or clinical examination. Massage, exercises, and sea-water bathing were advised, and the condition improved.

April 1928

While the foot was being massaged, intense pain was suddenly experienced at the lateral border. Examination showed definite muscle wasting in the left leg. There was acute tenderness toward the base of the fifth metatarsal, but the condition disclosed by the roentgenogram was as unexpected as it was surprising. The third, fourth, and fifth metatarsal bones, the cuneiforms, and the tarsal navicular had undergone such decalcification that they cast but little shadow and were attenuated in shape and deficient in detail. There was a fracture of the body of the fifth metatarsal. The right foot showed no abnormality, and roentgenographic examination of the knees, the hip joints, and the bones of the left leg in the neighborhood of the cartilages of the joints showed no alteration in bone structure.

After consultation with Prof. John Fraser, an attempt was made to correct an adduction deformity of the foot by means of a special boot. The administration of calcium and parathyroid was added to the existing treatment.

February 1929

Investigations undertaken by Prof. Fraser showed the blood calcium to be of normal quantity. The electric reactions of the muscles of the limbs, including the interossei and the plantar groups, were normal. A small portion of the fifth metatarsal was removed and examined. The bone lacked calcium and the cancellous spaces were enlarged. The ordinary marrow was entirely replaced by vascular fibrous tissue.

Roentgenograms were taken at regular intervals and showed a progressive increase in the decalcification. The foot became very unstable and useless, and so little tissue remained in the lateral half that the finger and thumb could be made to meet from

dorsum to sole. Distal to the mediotarsal joint there was a cyanotic tint; a growth of downy hair appeared; and a constant localized hyperhidrosis was present.

The question of possible benefit from periarterial sympathectomy was considered at this time, but in this case the operation was thought not to be justifiable. Bier's hyperaemia was used daily.

August 1929

At this time definite clinical improvement was noted,—the sweating was less marked, and the foot felt warmer and was more stable. The tissue deficiency was replaced to a certain extent by what felt like "sponge rubber". Walking had improved also, but, despite these reassuring signs, roentgenographic examination indicated an increase in the decalcification.

July 1931

At examination, five years after the original injury, the outline of the fifth metatarsal could not be distinguished and there was no bony substance in the third and fourth metatarsals. The shadow of the second metatarsal appeared more dense than two years previously. The patient was able to play nine holes of golf without undue fatigue. A slight injury, when the forepart of the foot was twisted between two planks, temporarily increased the disability, but, after a course of massage, with exposures to ultra-violet and infra-red rays, some improvement was seen in the muscles of the leg and foot.

1932

Local examination at this time showed that the foot had increased in length and in breadth. A slight degree of talipes calcaneo-cavus had developed; the tendency to adduction on walking was easy to correct, but most difficult to control efficiently. The temperature of the foot was normal, and excessive perspiration had ceased. Palpation of the metatarsal and

Fig. 1-A

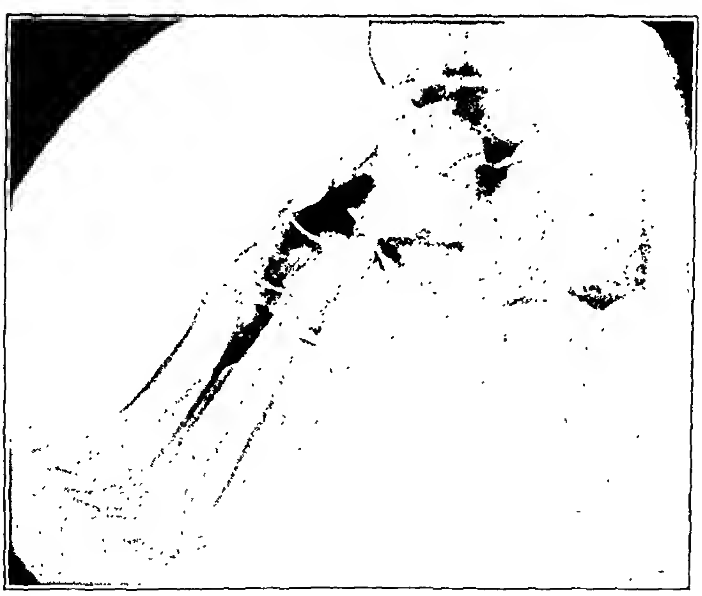

Fig. 1-B

1928. Anteroposterior and lateral views of left foot, showing decalcification of the metatarsal and of the mid-tarsal bones and a pathological fracture of the fifth metatarsal.

midtarsal regions showed distinctly that more resistance and solidity were present than a year previously. Roentgenograms showed a deformation of the talus and the calcaneum. The borders of their approximate surfaces were lipped and projecting, associated with apparently abnormal excavations.

1933–1936

During this period clinical improvement has been maintained. The patient walks and cycles freely, and states that she can play eighteen holes of golf and even dance in comfort.

On examination the foot shows no trophic disturbances or muscle weakness. The remaining bony tissues of the tarsus and of the metatarsus on the medial aspect have consolidated, forming a fixed adduction deformity. The lateral part of the foot contains no palpable bony tissue, but has definite stability. In spite of this improvement in function and in stability of the foot, an inspection of the most recent roentgenograms makes it impossible to say that the condition is completely arrested, although some of the remaining bones show denser shadows, suggesting areas of recalcification.

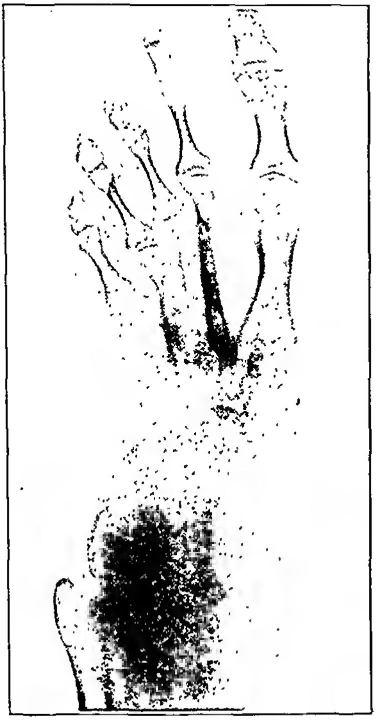

Fig. 2

1930. Progressive decalcification. The outlines of several bones are barely distinguishable.

Fig. 3

1932. Gradual disappearance of the third, fourth, and fifth metatarsals.

SUMMARY OF CASE

This case has been under observation during a period of ten years. The history may be summarized as follows:

June 1926: Localized injury to foot.

April 1927: Slight discomfort with "flat-foot". No abnormality discovered.

Fig. 4-A

Fig. 4-B

1935. Complete absorption of the third, fourth, and fifth metatarsals and of the midtarsal bones. Marked deformation of the talus and of the calcaneum. Points of denser shadow suggest attempts at recalcification in the remaining bones.

April 1928: Roentgenograms showing absorption of bones with pathological fracture of the fifth metatarsal.

1928–1933: Slow evolution with progressive decalcification as shown by roentgenograms.

1933–1936: Replacement of absorbed bones by tissue which has produced increasing stability and usefulness of the foot.

DISCUSSION

All those who examined the earlier roentgenograms in this case were agreed that the extreme degree of decalcification was most unusual and difficult to explain. Various suggestions were made: that the nature of the bone changes was on a parallel with the arthropathy seen in conjunction with certain nervous diseases; that there was a question of parathyroid tumor and hyperparathyroidism; that a spinal lesion, such as a spina bifida occulta, was present (the roentgenogram of the lumbar region showed no abnormality), etc. After careful local and general investigations had been carried out without helpful results, it was clear that the progressive decalcification and its localization in an otherwise healthy girl could not be dissociated from the injury sustained in 1926.

Sudeck first directed attention to the condition of post-traumatic decalcification in 1900, but the importance and far-reaching consequences of such disturbances of bone structure are only now being appreciated.

The recognition of the significance of these disturbances is due chiefly to the work of Leriche and his collaborators on the Continent, and of D. M. Greig in Scotland. Recently Middleton and Bruce published an interesting paper on "Post-Traumatic Osteodystrophy at Joints", based on a series of twenty cases.

As far as can be ascertained, no other case has been reported in the literature, which shows such an extreme degree of decalcification progressing over a period of so many years after the localized injury. Although the initial injury was probably more severe than was realized at the time, there was almost complete absence of pain throughout. In this respect the condition differs from the "post-traumatic painful osteoporosis" of Leriche and Fontaine.

Etiology

It is now generally accepted that decalcification is accompanied by hyperaemia. In this case hyperaemia was locally induced by injury, and certain bone changes might readily have followed, but no explanation can be given for the progressive decalcification of some bones and the actual absorption of others over such a prolonged period. It seems certain that injury caused a disturbance of the autonomic nervous system controlling the local blood supply, and it may be, as Greig suggests, that some alteration of an endosecretion added a centrally induced hyperaemia to prolong the process.

Prognosis

It is impossible to foretell whether or not recalcification can yet occur in the remaining bones of the foot. It is certain, however, that bones which have been absorbed are being replaced by tissues which cannot be seen roentgenographically, but which have sufficiently definite stability to give a functionally useful foot.

The author wishes to express his appreciation to Prof. John Fraser for his continued interest in this case, and also for permission to quote the results of investigations made while the patient was under his care in the Royal Infirmary, Edinburgh. Many helpful suggestions were also received from the late Mr. D. M. Greig, Curator of the Museum, Royal College of Surgeons, Edinburgh.

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OSTEOGENESIS IMPERFECTA

Report of a Case in an Adult

BY EDWARD PARNALL, M.D., ROCHESTER, NEW YORK

W. W., male, twenty-eight years old, an office worker, was sent to the writer with a complaint of pain in the dorsal spine and the feet, and inability to extend fully the left knee.

During early life and adolescence the patient had sustained seventeen fractures, involving every long bone in his body at least once. All of these fractures had healed uneventfully. There had been no fractures since the patient was about twenty years old. The trauma causing the fractures had nearly always been of a very trivial nature. During the two years prior to examination the patient had been increasingly troubled by a lame and bowed back, with pain especially on driving in an automobile. The fact that he could not fully extend the left knee seemed to throw him off balance in walking, and caused more back pain.

The patient presented a gnomelike appearance, standing with bowed back and holding his head, with pointed triangular face, down on his chest. He was obviously deaf, and the sclera of his eyes were a dusky blue. He walked with a left-sided list, due to a 30-degree flexion deformity of the left knee.

All the long bones showed obvious evidence of having been fractured. The alignment of the tibiae was such that the feet were kept in moderate valgus and continuously

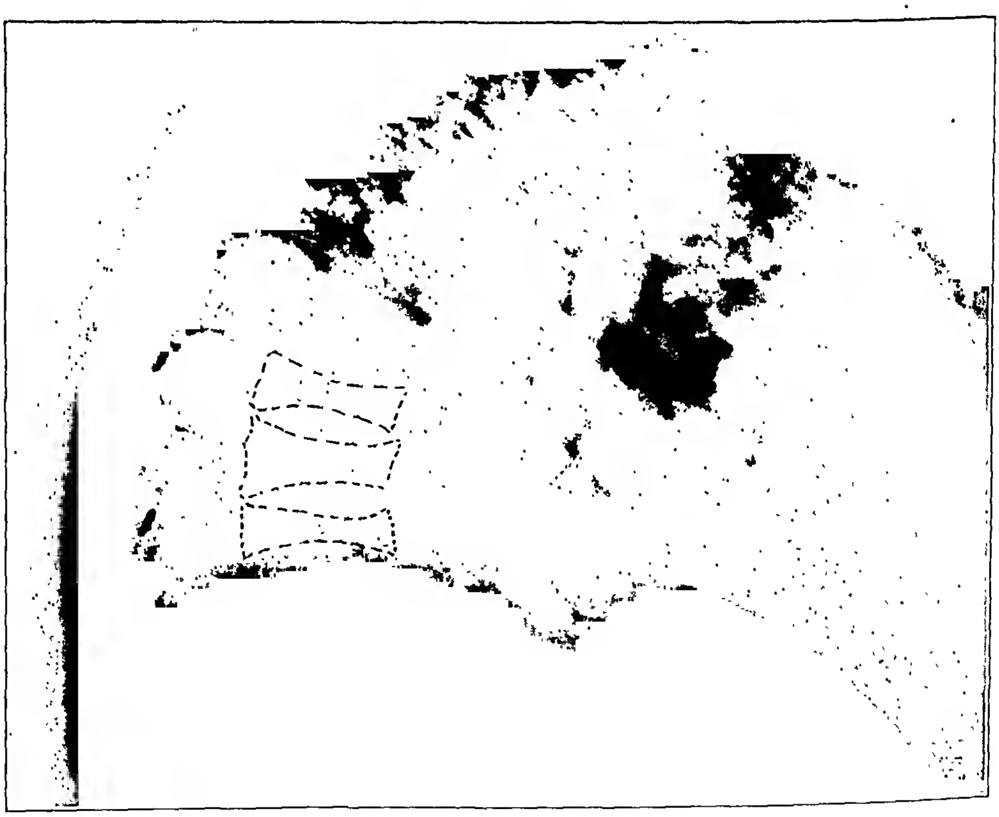


Fig. 1

Lateral view of dorsal vertebrae. The dotted lines bring out the amphicelous or biconcave appearance of three vertebrae. The same appearance is faintly visible in the other vertebrae.

strained. The knee lacked 30 degrees of full extension, even with forcing, which manoeuver caused pain. Obstruction seemed due to bony block.

There was considerable dorsal kyphos, especially at about the sixth dorsal vertebra, with pain on any attempt at hyperextension.

Roentgenograms showed generalized osteoporosis. The vertebrae were amphicelous, or "fishlike", in appearance, due to pressure from the intervertebral discs, with a considerable amount of wedging in the dorsal region. Roentgenograms of the left knee showed a block of bone lodged in front of the femur, just above the patella (presumably an old fracture which the patient had forgotten to mention).

The patient felt that he did not care to undergo operative removal of the bony fragment from the knee, and was put on a regimen of hyperextension, periodic rest, hot packs to the knee, and foot plates. Conservative treatment relieved the condition a little for about two months, at the end of which time the patient strained his back. He then readily agreed to enter the hospital.

The knee was explored, and it was found that the block of bone was indeed the upper fragment of the patella. This block was easily removed. After a few days the patient was placed upon a hyperextension frame, and the curve was gradually increased. At the end of two weeks the patient was fitted with a Taylor back brace, and discharged at the end of five weeks.

Calcium and phosphorus determinations were well within normal limits.

The patient gradually increased his activity, returning to work twelve months after operation. The brace was discarded after sixteen months. At times he had some trouble with the knee which had been operated upon, but this always cleared up with exercises. At the end of two and one-half years, he was able to work actively, to walk without a list, and to drive about in his car.

In this case, strangely enough, there is no history of any fractures nor of any blue sclera in other members of the family, as far back as can be determined. The only familial sign is deafness in the mother of the patient.

UNUNITED FRACTURES TREATED BY BONE DRILLING

BY E. R. EASTON, M. D., AND PRO. V. PREWITT, M. D., NEW YORK, N. Y.

From the Surgical Service of the Knickerbocker Hospital, New York City

Delayed union or non-union of fractures of the long bones, resultin from various causes, is not uncommon. The method of drilling to secur bony union has been used in numerous cases at Knickerbocker Hospita with uniformly good results.

Indications for this operation are:

1. Persistent mobility;
2. Malposition of the fragments, as shown by the roentgeno gram;
3. Lack of proper calcification.

The following nine selected cases represent a variety of condition to which the method is applicable.

CASE 1. A. J., male, twenty years of age, an office boy, fell down an elevator shaf in 1930 and sustained a compound fracture of the middle third of the left tibia and double fracture of the upper and lower portions of the left fibula. A slide graft was usec in 1931. This graft absorbed, and in 1932 the tibia was pierced ten or twelve times wit a bone drill. Solid bony union occurred after three months.

CASE 2. A. U., female, aged sixty-one, a housewife, slipped and fell on the left side fracturing the neck of the left femur. The fracture was reduced and a plaster spica wa worn for eight weeks. At the end of this period there was no union, and distinct slippin of the fragments was observed. Four days after reduction and retention with a Jone traction splint, the hip was drilled according to the technique of Bozsan. The splin was left in place for sixteen weeks; walking calipers were then applied. Roentgenogra phic examination, one year after operation, showed firm bony union with some absorp tion of the neck.

CASE 3. E. L., female, aged fifty-four, a housewife, fell in December 1934 anc fractured the surgical neck of the left humerus. Open reduction was performed or February 26, 1935, and the coracobrachialis and short head of the biceps were founc interposed between the fragments. The fragments were pierced eight or ten times witl a drill and fixed with two Easton nails* which were removed at the end of two months A roentgenogram, taken on April 10, 1935, demonstrated solid bony union.

CASE 4. V. P., female, a housewife, sustained a compound fracture of the left tibia and fibula at the junction of the upper and middle thirds. Union was delayed. The fragments were drilled by Dr. J. V. Bohrer and solid bony union was present after six weeks.

CASE 5. F. C., female, fifty-five years old, a nurse, fell on September 21, 1935, and fractured the right tibia and fibula at the junction of the middle and lower thirds. The patient was treated by cast in another hospital, and was discharged after three weeks. The cast was removed at the end of five weeks, and the patient was permitted to bear weight on the foot. Non-union resulted. The Wassermann test was three plus. The fragments were drilled on December 3, 1935, and a cast was applied. This cast was

* Triangular steel nails which can be driven into some of the drill holes, thus holding the fragments in alignment until satisfactory union has taken place.

worn for six weeks; during the last three weeks the patient was permitted to walk. At the end of six weeks solid bony union was present.

CASE 6. J. M., male, aged seventeen, was thrown from a motorcycle on February 7, 1934, and sustained a compound comminuted fracture of the right tibia and fibula at the junction of the middle and lower thirds. Nine months later, October 14, 1934, upon discharge from the hospital, examination showed posterior bowing, mobility, exuberant callus, and no calcification demonstrable by x-ray. These findings were present up to March 2, 1935, when the fracture was drilled by one of us (P. V. P.). Roentgenographic examination gave evidence of increasing bony union, although mobility was still present. On July 16, 1935, union was firm; there was no mobility; and calcification was evident in the roentgenograms.

CASE 7. G. W., male, fifty-four years old, a janitor, fell down a flight of stairs, fracturing the tibia and fibula in the distal thirds. There was considerable injury to the soft parts. Traction was maintained for one month by the Steinmann pin, followed by immobilization in a plaster cast. There was no evidence of union at the end of three months. Three weeks after drilling and immobilization in a plaster cast, union was firm.

CASE 8. N. C., a female, aged fifty-nine, fell on the sidewalk on November 7, 1935, fracturing the neck of the femur at its midportion. Eleven days after reduction by the Leadbetter method and application of a plaster spica, the fragments were drilled and fixed with Easton nails to prevent delayed union or non-union. The nails were removed seventy-two days later. The cast was taken off one month after removal of the nails, at which time there was roentgenographic evidence of early union. On June 15, 1936, the patient walked without support. The roentgenogram showed firm union at the fracture site.

CASE 9. B. W., a female, fell on January 28, 1936, sustaining a subcapital fracture of the neck of the femur. The Wassermann test was three plus. The fracture was reduced by a combination of the Murray and the Leadbetter methods, and a plaster spica was applied. Two weeks after reduction, the fragments were drilled and two Easton nails were inserted through a window in the cast to prevent delayed union or non-union. On June 30, the patient walked without support. The roentgenogram showed firm union at the fracture site.

The chief advantages of the drilling operation, as observed by the authors, are: (1) it creates an aseptic inflammatory process which increases local circulation; (2) pulverized bone is deposited within the fracture area; and (3) the viable cells promote the formation of so called "bony callus".

In the presence of active inflammation, the operation is contra-indicated, and should not be performed until it subsides. No other contra-indication has been observed.

SUMMARY

The authors have found that the bone-drilling operation involves less risk than the more formidable operations, and brings about more rapid union and gives more satisfactory results than any other method so far employed.

A METHOD OF TREATING FRACTURE OF THE CLAVICLE

BY GEORGE W. HAWLEY, M.D., F.A.C.S., BRIDGEPORT, CONNECTICUT

From the Orthopaedic and Fracture Service of the Bridgeport Hospital

The surgical objective in the treatment of fracture of the clavicle is to force the head of the humerus backward and with it the scapula, to which the outer end of the clavicle is attached. This has the effect of traction on the broken bone and avoids overriding and angulation of the fracture ends.

For the past ten years the following method has been used and has been found very satisfactory. It is carried out as follows. The patient, either standing or sitting on a stool, is requested to hold his head erect and to square his shoulders like a West Point cadet. The end of a strip of adhesive plaster is fastened to the skin in front of the head of the humerus. The opposite arm in abduction is pulled into hyperextension and used as a lever, while the plaster under strong tension is anchored to the opposite chest wall. This acts to pull the shoulder girdle back and to hold it securely. Several strips of plaster are applied in like manner, using a double thickness of plaster for added strength. As a rule, adhesive plaster is not effective unless it is at least of double thickness. Then a cap of adhesive is applied over the shoulder to anchor the anterior ends of the first plaster and to protect the site of

FIG. 1

Showing the method of applying the strips of adhesive plaster to exert a strong, backward pull on the shoulder girdle, using the opposite arm as a powerful lever.

FIG. 2

Showing the adhesive plaster in place as seen from behind. Note the pulling back of the shoulder girdle and how securely the position is held, also that the shoulder girdle is automatically elevated as the shoulder is retracted, preventing forward pull of the pectoral muscles and sagging of the outer fragment of the clavicle, due to gravity.

fracture. For the first week the arm is carried in a sling, following which the patient is allowed to take the arm out of the sling for meals. The sling is discarded when healing is under way and confidence returns. The plaster is reapplied every week for three to four weeks, using the same tension to hold the reduction.

FIG. 3

View from in front with the adhesive strips over the shoulder.

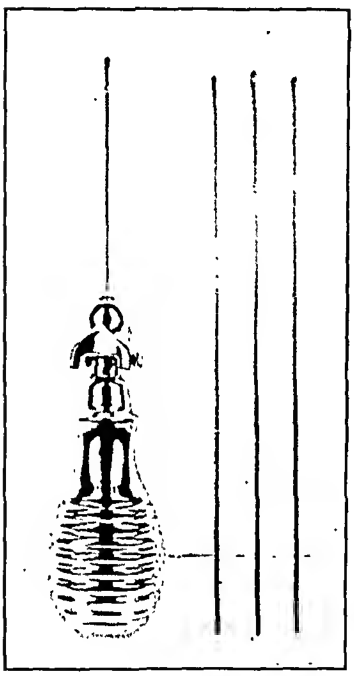
Some of the advantages of this method are these. It is simple and requires only ordinary adhesive plaster. It effects good reduction and holds the reduction. It requires no constant watchfulness and frequent adjustment; only weekly replacement is necessary. The chief objection to this method is that which applies to the use of any adhesive plaster,—the discomfort and irritation which it causes some individuals, although there are few who cannot comfortably stand it for the time required. For several years this method has been used as a routine with entire satisfaction. In rare cases, when union is complete and, in spite of all efforts to control it, the sharp end of one fragment insists on projecting upward, leaving an unsightly cosmetic blemish, the upper surface of the clavicle is smoothed off with a chisel through a small incision, with very satisfactory results.

AN INSTRUMENT FOR THE INSERTION OF KIRSCHNER WIRE IN PHALANGES FOR SKELETAL TRACTION

BY D. M. MEEKISON, M.B.(TOR.); B.SC., F.A.C.S.,
VANCOUVER, B. C., CANADA

The instrument described and illustrated below has been designed to facilitate the application of skeletal traction to fingers, particularly in treating compound fractures of the proximal phalanges. Nails, needles, and wires once placed have proved effective, but their insertion, either anteroposteriorly through the center of the finger-nail and the terminal phalanx, or laterally through the distal portion of the middle phalanx, has usually been extremely difficult.

The heaviest type of Kirschner wire has been selected as the most satisfactory material for use with this instrument. It is cut in appropriate lengths and the end is flattened and sharpened for cutting both clockwise and counter-clockwise. The handle of the instrument, of a form suggested by the graver of an etcher, is bulb-shaped and it nicely fits the palm. It has a special and rather stout chuck operated by a winged nut. This chuck firmly grips the Kirschner wire which inserts to the base of the handle for steadiness. Using a wooden chopping block (as for Hoke's arthrodesis) against the side or palmar aspect of the finger, it is a simple matter to push or to rotate the wire through, to remove the handle, and to cut off the excess wire. Incidentally a music-wire cutter has been found extremely useful for this purpose. It should be pointed out that traction to the wire of the banjo splint should be made by means of two elastic bands, one on either side of the finger. This precludes the possibility of pressure from an encircling band.



Skeletal traction thus inserted has also been found useful when applied to the thumb in cases of comminuted fractures of the lower end of the radius. In these cases traction has been maintained in the direct line of the radius to a heavy wire incorporated in the plaster. This produces almost exactly the Cotton-Loder position if directed a little ventrally, and it has undoubtedly prevented a possible occasional unhappy result in fractures of the wrist.

The writer is indebted to Dr. D. A. Murray of Seattle for the original idea of traction on the thumb in comminuted fractures of the lower end of the radius, but his dexterity in the use of adhesive tape could not be duplicated by the author,—hence the skeletal traction.

The trauma incidental to insertion of the wire has so far produced no ill effects, and such traction has not appeared to cause the patients any unusual discomfort.

CARE OF THE FEET AFTER BUNIONECTOMY

BY LEO J. MILTNER, M.D., PEIPING, CHINA

From the Division of Orthopaedic Surgery, Department of Surgery, Peiping Union Medical College, Peiping, China

Following bunionectomy, an important part of the physiotherapeutic care of the feet is the reeducation and redevelopment of the intrinsic muscles of the feet, especially of the interossei, of the abductor digiti quinti, and of the abductor hallucis. Correct footwear is necessary, but, even though worn, it will not necessarily prevent a recurrence of the deformity unless the small muscles governing the toes are restored to power. Therefore, after operation, the patient should be instructed to perform a long course of exercises. In many instances, before operation almost complete atrophy of the intrinsic muscles may be seen; after operation and two or three months of exercises, these same muscles usually show a very surprising return of active ability to adduct and abduct the toes.

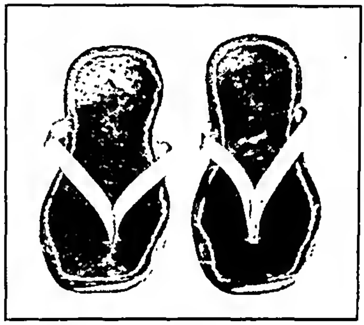


FIG. 1

The sandals have soles of felt and leather, with corrective elastic straps which separate the great toe from the second toe. Heels may be used if necessary.

The accompanying photographs illustrate the Japanese type of stocking and sandal, the use of which has proved very helpful in carrying out the above exercises. With this slipper, the patient is enabled to walk as soon as the wounds are healed. The elastic straps hold the great toe in the desired position of correction during walking. In addition, the toes are allowed considerable freedom, so that during walking the patient may perform active exercises, especially adduction and abduction of the toes. Even after the patient has been fitted with shoes, these sandals may be used to advantage at home in place of the ordinary house slippers.

FIG. 2

After bilateral removal of exostoses from the heads of the first and fifth metatarsals.

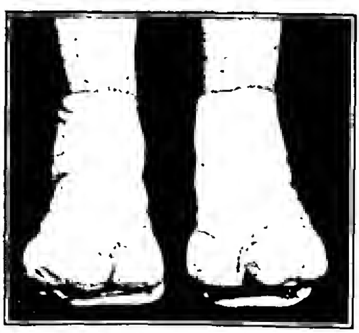


FIG. 3

The patient is wearing the special stockings and sandals, two weeks after bunionectomy operations.

A SELF-RETAINING BONE RETRACTOR

BY H. THEODORE SIMON, M.D., F.A.C.S., NEW ORLEANS, LOUISIANA

From the Department of Orthopaedic Surgery, Louisiana State University Medical Center, New Orleans

The writer designed this simple bone instrument, and has used it for a number of years with most satisfactory results. He feels that it should be described and made available for more general use.

The retractors are made of strips of sixteen-gage steel, bent in the form shown in Figure 1, to which are attached brass weights. The steel strips are spring-tempered. It has been found that three sizes are satisfactory for use in general bone surgery; however, any number of sizes could be made. The small size is made of a steel strip, six and one-half inches in length and three-quarters of an inch in width, with a weight of three and one-half ounces. The medium size is made of a strip, eight inches long and one inch wide, with a weight of six ounces. The large size is made of a nine-inch steel strip, one and one-eighth inches wide, with an eight-ounce weight. It should be noted that the curves in the rounded ends of the steel strips are made so as to cup into each other when slipped around the bone (Fig. 2). Two mated retractors make a complete instrument.

FIG. 1

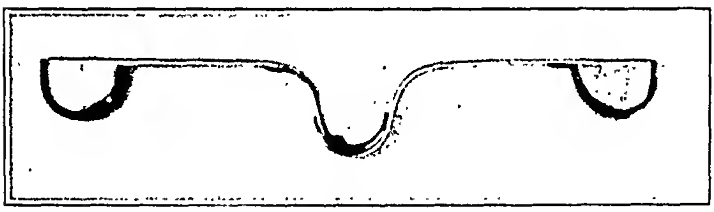


FIG. 2

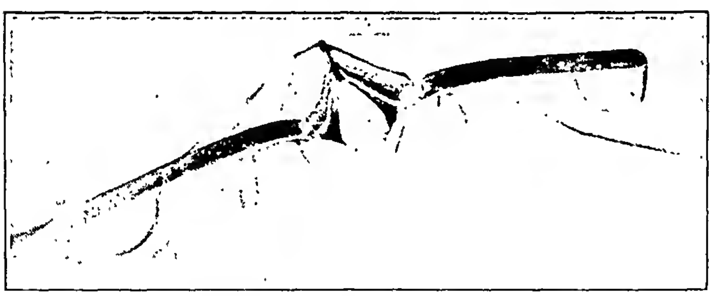


FIG. 3

The instrument has a threefold usage, acting as:

1. An elevator for the posterior periosteum;
2. A self-retaining bone retractor, eliminating one or more assistants;
3. An excellent protection for the soft parts, while the bone is being drilled, cut, and sawed.

A SELECTION OF KNOTS FOR USE WITH TRACTION-SUSPENSION APPARATUS

BY WM. DONALD DAVIDSON, M.D., EVANSVILLE, INDIANA

To be suitable for use with traction-suspension apparatus, a knot should be: (1) as simple as possible; (2) easily tied; (3) subject neither to slipping nor to jamming when in use; (4) easily untied when tension is relieved; and (5) neat in appearance. The following selection of knots is offered as having met these requirements in actual use.

The four basic knots in this selection are: the magnus hitch, the sheet-bend, the lark's-head, and the figure-of-eight. From the last, the packer's knot may be formed, while the bowline knot is fashioned from the sheet-bend. The operator should complete each knot by laying the free end of the cord beside the standing part, and by seizing them with a strip of adhesive wide enough to encircle both. This further reenforces the knot and gives it a neat and finished appearance.

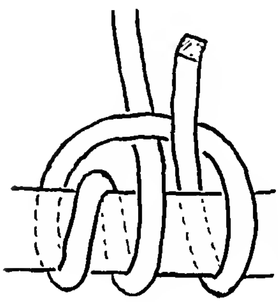


FIG. 1
Magnus hitch. Note all turns pass in same direction.

The magnus hitch (Fig. 1) is used to attach a cord to a splint or to a frame. It holds firmly without slipping, even when the strain is almost parallel to the bar. Two turns of the cord are made about the bar, and the free end of the cord is passed across in front of the standing part after the second turn has been completed. It is then carried about the bar, in the same direction as in the previous turns, to form a third turn. To complete the knot, the free end is brought up through the transverse portion of the cord and laid beside the standing portion. The knot must be drawn much tighter than that shown in Figure 1, which was purposely drawn loose for illustrative purposes.

The sheet-bend, or weaver's knot (Figs. 2, 3, and 4), is useful in joining two cords, either to give length or to attach the overhead suspension cord to the shorter cords, passing from one bar to the other on a Thomas splint. To give length, the free ends of two cords are crossed, and their point of junction is grasped with the left thumb and index finger. The left-hand cord, *A*, must be laid on top of the right-hand cord, *B*, as shown in Figure 2. With a flip of the right hand, a bight is thrown in *B*, passing it completely about its own free end and in front of the free end

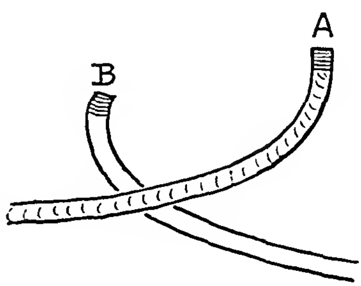


FIG. 2
Sheet-bend. Initial position. Left-hand rope on top.

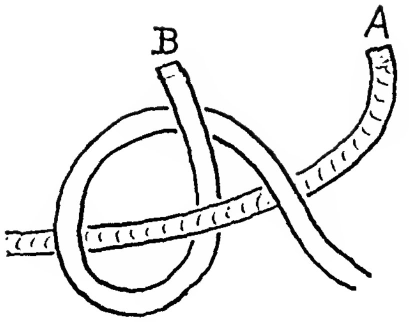


FIG. 3

Sheet-bend. Free end A projects through a bight thrown in B.

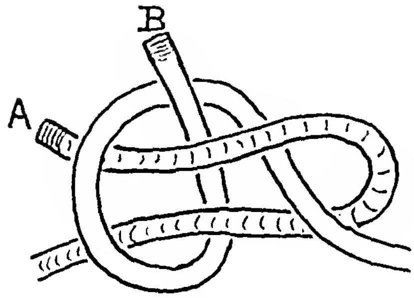


FIG. 4

Sheet-bend. Completed knot.

of A (Fig. 3). Free end A is then doubled back through this bight and grasped with the left hand, and the knot is tightened (Fig. 4). When used to fasten the overhead suspension cord to the shorter transverse cord, a bight is formed in the latter by grasping it so that the bight projects between the left thumb and the index finger; this bight takes the end position of cord A. The free end of the overhead suspension rope is brought through the bight, completely about the bight, and finally up through the loop thus formed. If cords of unequal size are to be joined, the larger of the two must be used as A.

The lark's-head knot (Fig. 5) is used to fasten a pulley ring to a cord. Both ends of a short length of cord are cut on a bias and rubbed on a cake of damp soap. They are then passed together through the ring, and the pulley is drawn along the doubled cord until only a small bight remains. The free ends are doubled back through the bight, and the knot is drawn tight. The pulley is then fastened to the Balkan frame by a magnus hitch in either end of the cord. If the axis of the pulley is to be the same as that of the bar to which it is attached, the hitches are thrown in opposing directions; if the axis of the pulley is to be at right angles to the bar, both hitches are passed in the same direction.

The figure-of-eight knot (Fig. 6) serves as a stopper knot, preventing a cord from pulling back through a spreader bar. The free end is doubled back and passed about the standing part and down through the bight. This knot has been employed, since it holds firmly, yet does not jam, and can be easily removed.

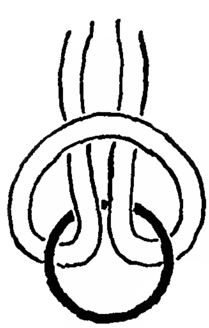


FIG. 5

Lark's-head knot.

The packer's knot (Fig. 7) gives a running loop, and is used in attaching weights for traction. It is formed from the figure-of-eight knot. A large loop is formed by passing the free end of a cord about the standing part, and then fashioning a figure-of-eight knot, using the cord of the loop as the standing part. The packer's knot is more secure than the ordinary slip knot which is commonly used.

The bowline knot (Figs. 8 and 9) forms a fixed loop. It gives an excellent

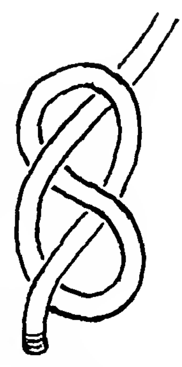


FIG. 6

Figure-of-eight knot.

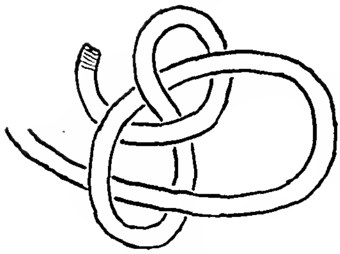


FIG. 7
Packer's knot.

hand grip. A short length of pipe may be threaded on the cord before the knot is tied, to give a better grasp. The knot is formed by making a large loop, by crossing the free end of the cord in front of the standing part. This crossing *a* is grasped with the right hand, palm down. The left hand, also palm down, grasps the proximal part of the loop some distance from *a*. The right hand is then turned palm up, carrying the free end around and up through the large loop (Fig. 8). A small bight is thus formed in the standing part, through which the free end projects. The crossing *c* is grasped with the left thumb and the index finger. The free end of the cord is carried around behind the standing part and down through the small bight to complete the knot (Fig. 9). It will be noticed that a sheet-bend has been formed in the cord. The running-bowline knot (Fig. 10) is formed by making a large loop, passing the free end of the cord around the standing part, and fashioning the bowline knot by making the small bight along the course of the large loop, and then completing the knot. This is the same procedure followed in fashioning the packer's knot from the figure-of-eight knot.

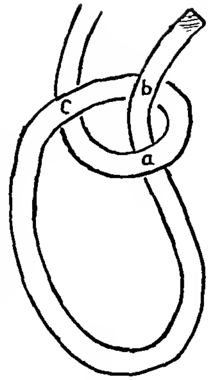


FIG. 8
Bowline knot. The small bight has been thrown in the standing part.

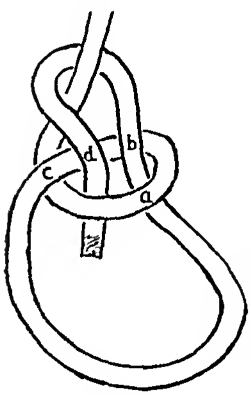


FIG. 9
Bowline knot. Completed form.

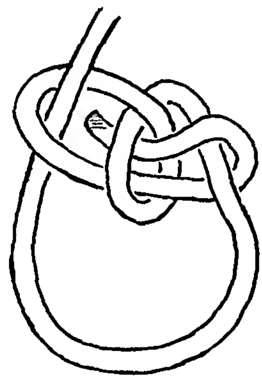


FIG. 10
Running-bowline knot.

With these simple knots, a traction-suspension apparatus may be set up with the assurance that slipping will not occur. While it is true that other knots may serve equally well, this selection meets every need. Since the knots are as simple as they are effective, they may be applied without difficulty.

A LEATHER TOE SPLINT *

BY A. M. RECHTMAN, M.D., F.A.C.S., PHILADELPHIA, PENNSYLVANIA

The toe splint shown in Figure 1 is used to supplant the cumbersome dressings commonly used to hold one or more toes in a proper attitude. This splint is simple to construct and easy to apply, and it occupies little space.

The splint is made from a single thin piece of walking *Leder* (imported German walking leather), one-sixteenth of an inch in thickness. It is firm but not rigid. The splint is constructed to conform approximately to the shape of the distal part of the sole of the foot, and it extends from directly back of the ends of the toes to the area beneath the metatarsal heads. The splint is fashioned somewhat smaller than the area of the sole of the foot to which it is fitted so that it will not be displaced by the stocking or by the shoe.

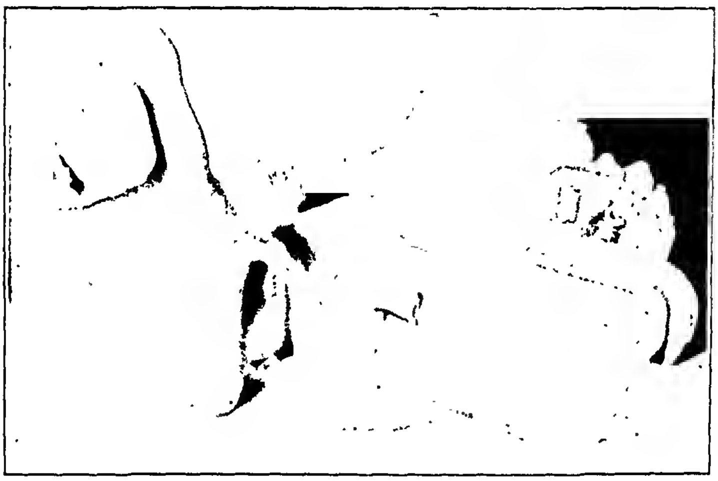


FIG. 1

Showing the splint in use. The patient, a male, aged fifty-four years, had had poliomyelitis. The right fifth toe was hyperextended. The extensor tendon was tenotomized. The left second toe was flaccid and plantar-flexed, with a painful callus on the distal end.

Two slits, three-fourths of an inch in length and parallel to each other, are cut in the support,—one upon either side of where the toe is to rest on the support. A piece of tape, three and one-half inches in length and five-eighths of an inch in width, is stitched to the under surface of the support and brought through the slit in the leather immediately adjacent. The tape is looped, so that it may be brought over the toe, and the end of the tape is brought through the second slit. The slits are cut sufficiently narrow to hold the tape firmly. Thus, the corrected attitude of the toe is maintained and no other fixation is necessary.

The splint is simple in construction and can be made by a leather worker or by a shoe-repair man. The physician may trim the toe splint with bandage scissors so that it will fit the foot.

The patient soon becomes accustomed to the presence of the splint on the foot and it may be worn with comfort. It has frequently been

* From the Orthopaedic Services of the writer at the Jewish Hospital, Philadelphia, at the Atlantic City Hospital, and at the Coatesville Hospital.

fitted to the feet of patients wearing Whitman plates. With the heat, moisture, and weight of the body, the splint soon conforms to the shape of the foot. It may be fashioned to fit any shaped foot, and one or more toes may be splinted. For hygienic reasons, it is advisable to have the splint made in duplicate, each to be worn on alternate days.

The splint has been successfully used as an aid in treating various congenital and acquired deformities of the toes and as a postoperative support to assist in maintaining the toes in a more normal attitude. Some of the specific conditions for which this toe splint has been used as an aid in treatment are: overlapping and underlying toes; dorsally hyperextended and dislocated toes (to relieve pressure); and hammer toes and bunions (as a preoperative and postoperative dressing). A preliminary tenotomy of the flexor or extensor tendons of the affected toe may at times be advisable before the splint is applied.

AN ADAPTED BANJO SPLINT

BY ROBERT ALAN HICKS, M.D., TUCSON, ARIZONA

There is a constantly growing conviction among those treating arthritis that one of the major contributions which the physician can make to the patient is the prevention of deformity. Simple position, manual reduction, etc., will not usually accomplish this end. Traction is of enormous assistance. In every patient with chronic proliferative arthritis the development of the earliest or slightest tendency to fusiform fingers should warn the practitioner that ulnar deviation in the metacarpophalangeal joints may develop in the near future, with never-to-be-corrected erosion of the lateral bony prominences at these joints. At the same time, flexion

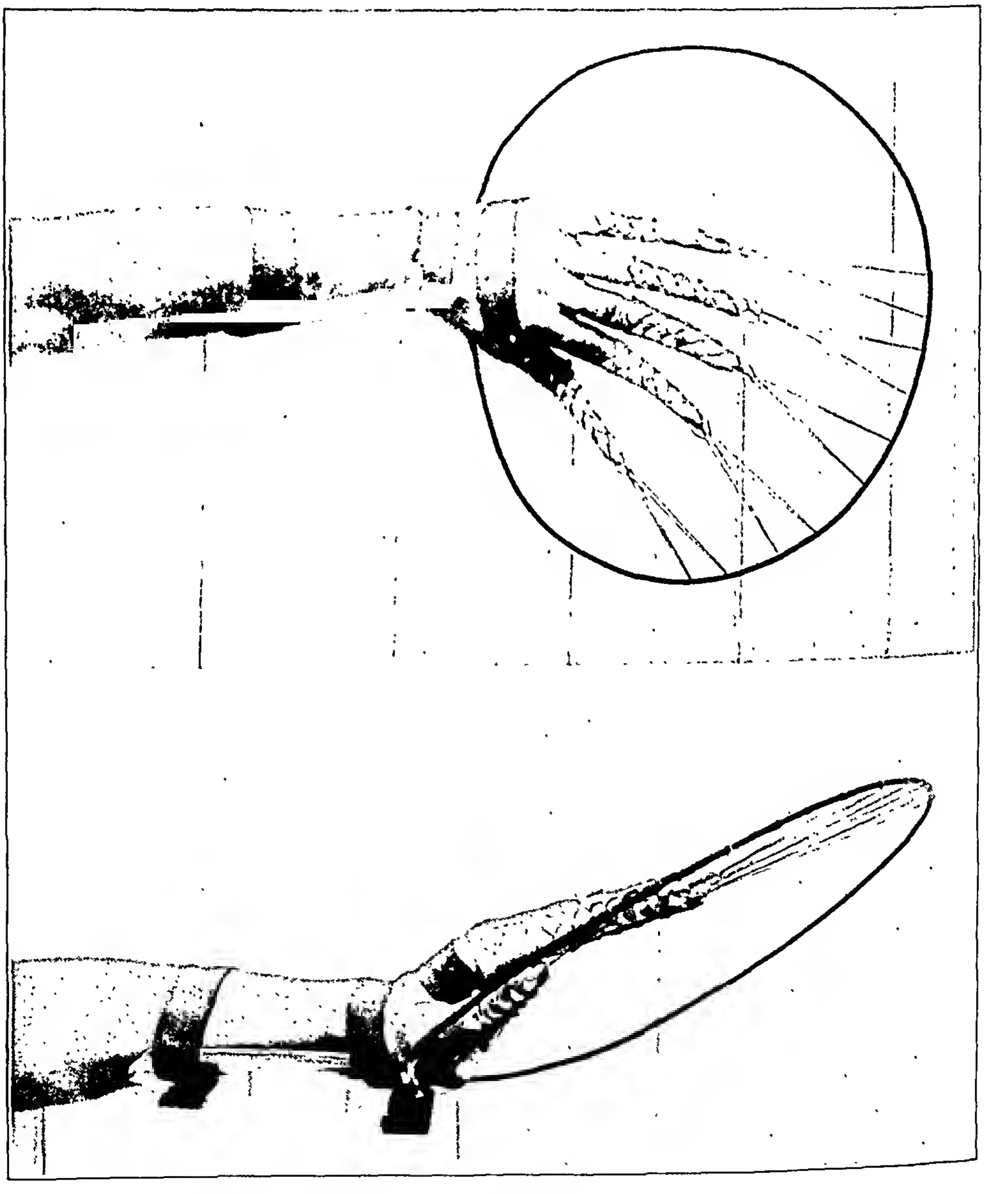


FIG. 1

contracture of the first interphalangeal joint and overstretching of the last phalangeal joint may be anticipated with the development of the well-known "bayonet deformity". This deformity may be prevented by the early application of traction by means of the splint shown in Figure 1.

In association with the hand and finger deformity mentioned above, there is frequently a volar contracture of the radiocarpal articulation. The wrist rarely loses the motion of volar flexion, but often in arthritis dorsal flexion is markedly diminished. Accordingly the splint is made with an adjustable cock-up palmar dome.

The splint is made of light, strong aluminum with enough flexibility so that it will fit any adult arm and function equally well either on the right or on the left hand. It may be bent by firm, steady finger pressure at the portion which lies under the carpal bones. Bending at this point will fit it smoothly and give the desired degree of "cock-up" to the palmar dome. With progressive correction of the volar contracture at the wrist, the degree of cock-up may be increased, and the splint is made strongly enough to enable it to maintain its contour after each adjustment.

In applying the apparatus, finger stalls are slipped over the fingers and attached to the wire loop by simple, small, rubber bands. These bands may be applied in any number, and any degree of traction may be obtained. The finger stall employed is actually designed as a plaything, being meant to grip the finger more tightly the harder the pull is made to remove it.

For the first few days of traction, the finger is pulled in the line of deformity, with the purpose of relaxing the capsular ligaments. The rubber bands are then slowly moved toward the radial side of the spring-wire arch of the splint until overcorrection is attained. The thumb may be treated similarly.

From the standpoint of simple mechanics, the splint pictured has been developed with every regard to the weak, painful, atrophic hand of the arthritic patient. Its lightness and comparative convenience of application make it a device practical from all standpoints to meet a very highly specialized need in the treatment problems of arthritis.

A TOE SPLINT

BY EDWARD N. REED, M.D., F.A.C.S., SANTA MONICA, CALIFORNIA

The ideal dressing for fracture of the phalanges of the toes should give fixation and, in the case of the first and fifth phalanges, protection from pressure. At the same time the dressing should permit the wearing of a shoe.

These fractures are not serious injuries, since they heal readily and very seldom cause any prolonged disability. However, they are very uncomfortable, unless adequately immobilized and protected from pressure; and dressings which afford protection and fixation are often too bulky to allow wearing a shoe.

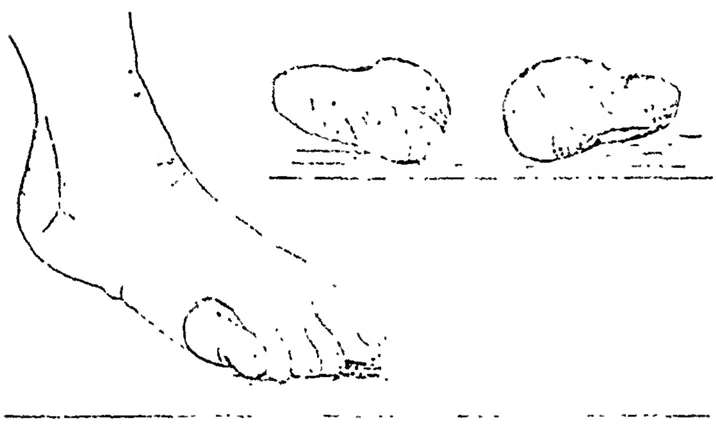


FIG. 1

A dressing which has been found to meet the requirements is composed of a thin metal shell, fitted around the lateral aspect of the digit, extending just beyond the distal end and proximally for an inch or more on the side of the forefoot. The material used has been 22-gage sheet nickle-silver or zinc. A model of the area to be covered by the shell is made by cutting three layers of "hard-coated" plaster bandage to the desired shape, and wetting and molding them over the area to be splinted. When the plaster has set, the mold is carefully loosened, removed, and allowed to dry thoroughly.

The sheet metal is cut to this pattern and then drawn, with a ball-peen hammer on a lead block, so that it fits the mold exactly. This is easily and quickly done with the aid of a very thin-jawed plier, to crimp the metal where necessary to meet creases and folds. The edges of the completed shell should be rolled out slightly with the peening hammer to prevent their cutting into the skin. If desired, such shells can be quickly lined with a layer of moleskin adhesive plaster or chiropodists' thin, adhesive felt, which gives assurance of comfort but adds very little to the thickness. In spite of its thinness, the finished shell is remarkably stiff, because the surfaces curve in two or more planes. It can be applied directly to the skin surface and fixed in position by encircling adhesive strapping. For the first and fifth digits, the application is made to the lateral aspect, in order to protect against lateral pressure, as well as to give fixation. For the others, the shell is made to fit the dorsal

aspect, for the purpose of fixation only. The shoe can then be put on without difficulty and the patient can proceed at once with his usual activities, without pain or discomfort.

With a little experience these shells can be made directly from the metal, without a model, and tried on the digit from time to time as they are hammered out. The whole procedure requires only a short time, and can be completed while the patient waits.

A SIMPLE AND EFFICIENT FINGER SPLINT

BY VERNON L. HART, M.D., MINNEAPOLIS, MINNESOTA

An infected or injured finger frequently requires proper splinting. A simple and light splint, which provides comfort, protection, traction and countertraction, and permits active exercises of the joints, inspection, and roentgenographic studies of the bones, is shown in Figures 1, 2, and 3.

FIG. 1

FIG. 2

FIG. 3

The entire splint is made from a piece of sheet aluminum, one-sixteenth of an inch in thickness. Fingernail, skin, or skeletal traction may be used in a line determined by the bend of the splint.

A NEW ELECTRIC MENISCOTOMY KNIFE

BY VINCENT LEGGIADRO, M.D., PORT CHESTER, NEW YORK

Although great strides have been made in our knowledge of the diagnosis and pathology of the internal semilunar cartilage, the surgical treatment has not progressed and the operative technique has shown very little advance in the last decade. With all the attempts made by use of different types of knives, and through different approaches, the difficulty in freeing the posterior quarter of the cartilage has not been overcome. The author has devised a new electric meniscotomy knife, which is simple and practical and has proved eminently satisfactory for the complete removal of the internal semilunar cartilages through the anteromedial approach. By the use of this knife, this operation is performed with a minimum of trauma and little effort, and in far less time than that required by any of the procedures in previous use.

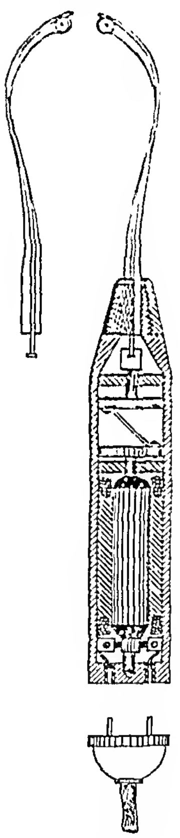


FIG. 1
One-third actual size.

The instrument consists of a very narrow, elongated, S-shaped, stainless-steel armed guide, on the distal end of which is a narrow, rounded blade, completely guarded on its outer aspect and only partially exposed on its concave side. The blade is attached to a narrow, steel, spring rod, which, in turn, is connected to the shaft of a special electric coil or reciprocating shaft of a small electric motor by means of an easily operating lock. This lock permits the quick interchange of knife blades. The blade is tilted about 25 degrees on its axis. It moves forward and backward, with a stroke of two-sixteenths of an inch, having a speed up to about 4,000 strokes per minute. There are two knives —one with a curvature to the right, the other to the left— which are provided with protruding guards on the top. The knife with the distal curvature directed to the right is for the removal of the external cartilage of the right knee or the internal cartilage of the left knee. The other, with the curvature to the left, is for the removal of the opposite cartilages.

The blade guard on its outer aspect is purposely devised to steady the tissue to be severed. The coil or motor is completely enclosed in a steel housing, which is especially constructed to permit sterilization. The vibrations produced by the coil or by the motor are negligible. The instrument is universal and may be used either with an alternating or with a direct current. The frequency and strength of the stroke can be regulated at will by means of a rheostat and rectifier. The instrument is further controlled by a foot switch.

SPLINT FOR CORRECTION OF FINGER CONTRACTURE

BY EDGAR D. OPPENHEIMER, M.D., NEW YORK, N. Y.

Of the various splints used for finger contractures few are practical. The attempt to correct the flexion in the two distal digital joints is usually nullified by the hyperextension of the metacarpophalangeal joint. The banjo type of splint, with traction, is difficult for a patient to apply and presents mechanical slips. Of course, where the flexor tendons are adherent, no splint has any effect, for the value of any apparatus depends for its success on the possibility of stretching the tissues and obtaining the correction. The amount of pressure or force that can be used on a digit is small on account of the surface accessible for the pressure. However, the amount of force necessary is often not great and much can be accomplished by prolonged and frequent stretching in a way that is not uncomfortable.

The apparatus here described is extremely simple. Its action is not nullified by the hyperextension of the metacarpophalangeal joint or wrist. The splint is readily applied by the patient. It is inexpensive, easily adjusted, and has proved effective in overcoming and preventing the flexion contractures of fingers, which are so common after injuries, infections, and nerve lesions.

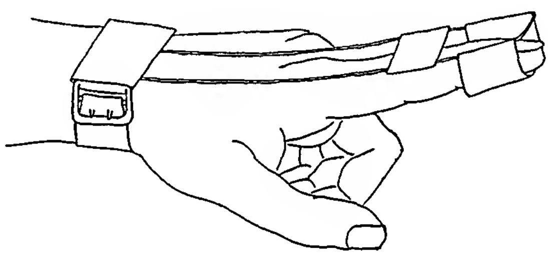


FIG. 1

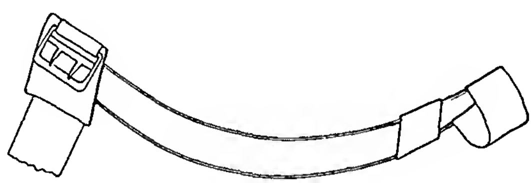


FIG. 2

The apparatus consists of two parallel spring wires or of one wire bent on itself. Ten to twenty-gage piano wire is used, depending upon the tension desired. At the distal end is a loop or sling of sheet metal, about three-fourths of an inch in width. Made from the ordinary tin can, it is soft-soldered on by an alcohol lamp. Central to it a small platform is similarly soldered, which exerts pressure over the second phalanx, while the distal sling is giving pressure over the pad of the finger. At the level of the wrist a larger piece of metal is soldered on and to this a strap and buckle are attached, which fasten around the wrist. One or more of these finger stretchers can be soldered onto the wrist piece. The piano wire has a natural curve; this is used with the convexity forward and ordinarily makes an arc equivalent to a third of a circle. If the tin is covered with moleskin adhesive, the sharp metal edges can be avoided, the

pressure somewhat softened, and the splint made presentable. The wires can also be covered if the pressure on the dorsum of the hand is uncomfortable. The splint is applied by inserting the finger through the loop and fastening the strap about the wrist.

These splints can be made to suit a particular case in a few minutes without any special tools. They are durable and easily adjustable, and the spring tension can be changed as correction is obtained. When soiled, the moleskin is readily changed. The distal joints are held in extension. The direction of force in the upper part of the wire curve is centrifugal against the hyperextension of the metacarpophalangeal joint. The patient can readily apply this splint in his free time for half-hour periods several times a day; thus, while he is otherwise occupied, the digits can be stretched. The force used should not be great. In cases where stretching is possible, the author has found this splint of great practical value.

News Notes

The Fifth Annual Convention of the **American Academy of Orthopaedic Surgeons** will be held at the Hotel Cleveland, Cleveland, Ohio, on January 10, 11, 12, 13, and 14. A most interesting scientific program has been arranged by the Program Committee, which will include the following:

TUESDAY, JANUARY 12

Morning Session

Injuries to the Accessory Processes of the Vertebrae.
Dr. Merrill C. Mensor, San Francisco, California.
Tendon Transference—Late-Result Study.
Dr. Charles W. Peabody, Detroit, Michigan.
The Cineplastic Amputation.
Dr. Henry H. Kessler, Newark, New Jersey.
Phosphatase. Its Clinical Significance.
Dr. C. Leslie Mitchell, Detroit, Michigan.
The Roentgen Ray in the Assessment of Growth and Health.
Dr. T. Wingate Todd, Cleveland, Ohio.

Executive Session — 12:00 Noon.

Afternoon Session

President's Address.
Dr. Melvin S. Henderson, Rochester, Minnesota.
Torticollis.
Dr. Frederick C. Kidner, Detroit, Michigan.
Symposium on Shoulder Disability—Dr. E. A. Codman, *Chairman:*
Classification of Shoulder Lesions.
Dr. E. A. Codman, Boston, Massachusetts.
Muscle Transplantation for Circumflex-Nerve Paralysis.
Dr. Frank R. Ober, Boston, Massachusetts.
Rupture of the Supraspinatus Tendon.
Dr. Leo Mayer, New York, N. Y.
Symposium on Osteomyelitis—Dr. H. Winnett Orr, *Chairman:*
Factors in the Etiology of Osteomyelitis and Their Relation to Treatment.
Dr. H. Winnett Orr, Lincoln, Nebraska.
The Pathology of Acute and Chronic Bone Infections.
Dr. Dallas B. Phemister, Chicago, Illinois.
The Rôle of the Infectious Organism in Osteomyelitis.
Dr. Ward J. MacNeal, New York, N. Y.
The Rôle of Bacteriophage in Wound-Healing in Osteomyelitis.
Dr. Fred H. Albee, New York, N. Y.

WEDNESDAY, JANUARY 13

Morning Session

Schanz Osteotomy for Fracture of the Neck of the Femur.
Dr. Herman Schumm, Milwaukee, Wisconsin.
Circulatory Studies and Nutrition of Head of Femur.
Dr. W. Eugene Wolcott, Des Moines, Iowa.
The Value of Early Weight-Bearing in the Treatment of Fracture of the Neck of the Femur.
Dr. Samuel Kleinberg, New York, N. Y.

A Reconstruction Operation for Old, Ununited Fracture of the Femoral Neck.
Dr. Paul C. Colonna, New York, N. Y.
A New Technique for Nailing Fractures of the Neck of the Femur.
Dr. José Valls, Buenos Aires, Argentine.

Afternoon Session

Bone Marrow and Its Relation to Orthopaedic Surgery.
Dr. Charles B. Huggins, Chicago, Illinois.
Some Aspects of the Utilization of Sulphur Compounds in Health and Disease.
Dr. Howard B. Lewis, Ann Arbor, Michigan.
Symposium on Fractures of the Ankle—Dr. Philip D. Wilson, *Chairman:*
Etiology and Classification of the Various Types of Fractures.
Dr. Sumner Roberts, Boston, Massachusetts.
Treatment of Severe Fractures of the Ankle.
Dr. Robert D. Schrock, Omaha, Nebraska.
Operative Methods in Treatment of Severe Ankle Fractures.
Dr. William Darrach, New York, N. Y.
Treatment of Malunited and Disabling Ankle-Joint Fractures.
Dr. J. S. Speed, Memphis, Tennessee.

THURSDAY, JANUARY 14

Morning Session

Arthroplasty of the Hip Joint. An End-Result Study of Seventy-Nine Unselected Cases.
Dr. Halford Hallock, New York, N. Y.
The Effect of the Periosteum on the Position of Fracture Fragments.
Dr. Beveridge H. Moore, Chicago, Illinois.
Roentgenographic Diagnosis of Tuberculosis of the Joints.
Dr. Albert B. Ferguson, New York, N. Y.
The Pathology of Hematogenous Osteomyelitis.
Dr. Dallas B. Phemister, Chicago, Illinois.
Dr. C. H. Hatcher, Chicago, Illinois.
Tuberculosis of the Spine in Children.
Dr. Edwin F. Cave, Boston, Massachusetts.

Afternoon Session

Seminar on Low-Back Pain—Dr. Joel E. Goldthwait, *Chairman:*
The Anatomical Structure of the Lumbar Region, Including Variations.
Dr. Theodore A. Willis, Cleveland, Ohio.
The Operative Treatment.
Dr. Edward L. Compere, Chicago, Illinois.
Sacrococcygeal Lesions.
Dr. J. Albert Key, St. Louis, Missouri.
Fasciotomy for Sacro-Iliac Lesions.
Dr. Alan DeForest Smith, New York, N. Y.
The Mechanics of the Lumbosacral and Sacro-Iliac Joints.
Dr. Lloyd T. Brown, Boston, Massachusetts.
Nerve-Root Pain Due to Intraspinal Protrusion of Intervertebral Discs. Diagnosis and Surgical Treatment.
Dr. J. Grafton Love, Rochester, Minnesota.
The Compensation Aspects of Low-Back Conditions.
Dr. Howard L. Prince, Rochester, New York.

Executive Session — 5:30 P.M.

The Annual Banquet will be held in the Ballroom of the Hotel Cleveland on Wednesday evening, January 13, and at that time the Presidential Award will be made, the Scien-

tific Awards will be presented, and the newly elected Fellows will receive their certificates. The speaker at the Banquet will be Prof. T. Wingate Todd.

The local committee have arranged for a large number of carefully selected scientific exhibits and the technical exhibits will also be of interest to the members.

Six radio broadcasts, sponsored by the Academy, have been arranged in connection with the Convention.

The officers of the Academy for the current year are:

President: Dr. Melvin S. Henderson, Rochester, Minnesota.
President-Elect: Dr. A. Bruce Gill, Philadelphia, Pennsylvania.
Vice-President: Dr. W. B. Carrell, Dallas, Texas.
Treasurer: Dr. E. B. Mumford, Indianapolis, Indiana.
Secretary: Dr. Philip Lewin, Chicago, Illinois.

Dr. Arthur Krida and Dr. John C. McCauley, Jr., have announced the removal of their offices to 791 Park Avenue, New York, N. Y.

Dr. Charles M. Allaben, 114 Murray Street, Binghamton, New York, announces the association with him of Dr. Alvin R. Carpenter.

The Sixth Walter M. Brickner Lecture at the **Hospital for Joint Diseases** was given on Thursday evening, November 19, by Dr. George R. Minot of Boston. His subject was "Anaemia: Etiology, Diagnosis, and Treatment".

The second 1937 examination of **The American Board of Orthopaedic Surgery** will be held in conjunction with the meeting of the American Medical Association at Atlantic City in June. All applications must be made by May 1 to the Secretary, Dr. Fremont A. Chandler, 6 North Michigan Avenue, Chicago, Illinois.

Effective with the current issue of *The Journal*, the price of foreign postage has been increased to seventy-five cents, making the subscription price to foreign countries $5.75.

At the Eighteenth Annual Meeting of the **Société Française d'Orthopédie**, held in Paris on October 9, 1936, the principal subjects considered were:

1. "Spondylolisthesis", discussed by Dr. Guilleminet of Lyons. Dr. Guilleminet emphasized the importance of the roentgenographic interpretation of these deformities, as well as the pathogenesis and the treatment. He also described the interesting results which have been obtained by surgical treatment either by the double graft or by transverse iliac arthrodesis.

2. "Malunion of the Bones of the Tarsus", presented by Dr. Padovani of Paris. Dr. Padovani discussed the different operative procedures directed toward the correction of these malunions and gave the indications for the operations in the different cases. The object must always be to reestablish the normal relationship between the foot and the leg and to preserve a certain amount of motion in the tibiotarsal articulation.

The First **International Conference on Fever Therapy** will hold its sessions on March 29, 30, and 31, 1937, at the College of Physicians and Surgeons, Columbia University, New York City. The first day will be devoted to the discussion of physiology, pathology, and methods of production of fever. The second day is to be spent in the con-

sideration of miscellaneous diseases treated by fever, such as chorea, rheumatic carditis, ocular diseases, arthritis, leprosy, meningococcus infections, undulant fever, tuberculosis, tumors, skin diseases, etc. The morning of the third day is to be devoted to the consideration of syphilis. In the afternoon of the same day, the treatment of gonorrhoea by fever is to be discussed under the chairmanship of Dr. Stafford L. Warren, Strong Memorial Hospital, University of Rochester, Rochester, New York.

Ministries of Health from many countries have indicated their intention to send official representatives to the Conference. The official language of the Conference is to be English. Baron Henri de Rothschild of Paris is General Chairman of the International Conference on Fever Therapy. Dr. Walter M. Simpson, Dayton, Ohio, is Chairman of the American Committee. The General Secretary is Dr. William Bierman, 471 Park Avenue, New York City.

The Third Congress of the **International Society of Orthopaedic Surgery and Traumatology** was held in Bologna on September 21 to 24 and in Rome on September 25. There was a large attendance and most of the countries of the world were represented.

The name of the Society was changed from The International Society of Orthopaedic Surgery to The International Society of Orthopaedic Surgery and Traumatology.

The meeting was held at the Rizzoli Institute in Bologna and at the Orthopaedic Clinic in University City in Rome. Clinics were given by Prof. Vittorio Putti and his associates on the third and fourth days of the Congress. Seven members from Brazil were elected as well as three members from Chile.

Dr. Hermann Gocht of Berlin was elected President of the next Congress and Dr. Fred H. Albee of New York City was elected Vice-President of the Society. The symposia designated for the next Congress are: (1) The Treatment of Congenital Dislocation of the Hip; and (2) Fracture of the Neck of the Femur. The next Congresses will take place in Berlin in 1939, and in New York City in 1942.

Information has been received about the activities of the **Palestine Society for Crippled Children.** It is non-sectarian and is affiliated with the Society for the Aid of the Crippled in Palestine, Inc., State of New York. Its object is to aid in every possible way the rehabilitating of the crippled child and adolescent in Palestine and to make them self-supporting. There is a large consulting staff and advisory council composed of prominent officials. In addition to facilities for hospitalization, there is an Out-Patient Department in which, during the first six months of this past year, 933 free treatments were given. There is a Department of Social Service and of Occupational Therapy. Some of the workers are volunteers. An industrial school is maintained by the Society and in this the patient is taught a trade which will make him self-supporting. The Society, working with the Government, attempts to obtain statistics of the number of cripples in Palestine and to devise ways and means of preventing the advent of deformities in children, as well as to establish principles for rehabilitation.

The Congress of the **Czechoslovakian Orthopaedic Society** was held in Bratislava on June 27 to 30. It was opened by the President, Prof. Mikula, with clinical demonstrations. At the beginning of the scientific session, the President gave a report on his treatment of various diseases of the joints, in which he considered both operative and conservative methods. For acute joint conditions, he recommended opening and irrigation for forty-five minutes, followed by closure and immobilization of the joint.

The subject of gonorrhoeal arthritis, particularly in the knee, was considered by Dr. Manzoni of Zagreb. Docent Dr. Treger of Bratislava spoke on the importance of serological reactions in gonorrhoeal arthritis, and Primarius Dr. Račanský of Zlin discussed the diagnosis and therapy. Primarius Dr. Minář of Ljubljana reported a case of gonor-

rhoeal osteochondritis of the humerus, and the conservative treatment of gonorrhoeal arthritis by injections of electrargol was discussed by Dr. Hanák.

For treatment of fractures of the femoral neck, Prof. Zahradníček of Prague recommended conservative treatment, or operative treatment only after the conservative treatment had failed. Prof. Frejka of Brno advocated immediate operation wherever possible, to obtain osteosynthesis either by graft or by nail.

The results of experimental work with synovial fluid were reported by Dr. Vavrda of Bratislava.

Assistant Dr. Jeřábek of Prague spoke on the principles and the results of operative treatment of joints, with particular emphasis on the necessity of careful consideration of the indications, especially for plastic operations.

Prof. Frejka gave a general report in regard to diseases of the joints, laying stress on the necessity of distinguishing infections from traumatic or degenerative toxic changes of neoplasm.

Other communications were made by Dr. Havránek, Košumberk; Docent Dr. Burian; Prof. Diviš, Prague; Dr. Pavlík, Brno; Dr. Pavlanský; Dr. Erneyi, Bratislava; Prof. Cmunt, Prague; and Prof. Kimla, Prague.

Prof. Zahradníček was elected President for the two subsequent years. The next Congress is to be held in September 1937 at Belgrade.

The Eighth Annual Meeting of the **American Society for the Study of Arthritis** was held on December 3, 4, and 5 in New York City, with headquarters at the Waldorf-Astoria. Dr. Reginald Burbank of New York City presided.

In the morning of December 3, there was an informal round-table discussion of arthritic problems with particular attention to liver function, gastro-intestinal absorptive phenomena, and allergic manifestations in their relation to arthritis.

The afternoon was devoted to the presentation of papers. Dr. B. H. Huggins of Evanston, Illinois read a paper on "Non-Arthritic Problems in Differential Diagnosis" in which he discussed some of the complicating factors which require special study and adequate roentgenographic examination before the diagnosis can be definitely clarified.

Dr. R. L. Jeffery of Seattle presented a paper entitled "Résumé of Cases Treated with Complement-Fixing Antigens, According to the Burbank-Hadjopoulos Technique". Corollary series of cases were presented with the results of treatment by different methods. Dr. Jeffery stressed the advantage of the complement-fixing antigens as opposed to the socalled pathogen selective.

Dr. Carl R. Comstock of Saratoga Springs reported on the "Regimen for Arthritis as Employed at Saratoga Springs". He emphasized the benefit derived from a careful regimen accompanied by cautiously given baths, manipulation, and massage.

In the evening, the Eighth Annual Open Meeting of the Society was held at the New York Academy of Medicine. Dr. Laurence Mayers of Chicago gave a humorous dissertation on the infinite number of drugs which can be purchased through the druggist by the arthritic patient and stressed the uselessness of most of these preparations.

The second paper, by Dr. Ralph R. Mellon of Pittsburgh, who, for many years, has been working on dissociation phenomena in bacteria, demonstrated how a human hemolytic streptococcus S-type colony was dissociated into a graded series of stabilized variants ending in a non-hemolytic diphtheroid. Dr. Mellon pointed out that mutants could increase in pathogenicity from five thousand to two billion times.

Mr. H. Warren Crowe, Chief of the Charterhouse Rheumatism Clinic, London, gave an address on the "Differential Sedimentation Test in Arthritis", which he considers a more useful diagnostic measure than the blood sedimentation rate. This is a colloidal reaction of the serum proteins and can be successfully used as a control test in the treatment of infection. He feels that the research which resulted in this test is fundamental and that the test itself will be applicable to many fields of medicine, but particularly to arthritis and asthma.

On the morning of December 4, there was again round-table discussion with especial

reference to dissemination of infection from focal areas, menopausal manifestations, and thyroid dyscrasias.

At the afternoon meeting a most interesting demonstration of "Fascial Adhesions" by air injection was given by Dr. Charles Murray Gratz of New York City.

The second paper, by Mr. H. Warren Crowe of London, discussed the rôle of roentgenography in the diagnosis and the control of treatment of arthritis.

Dr. L. G. Hadjopoulos of New York City demonstrated "Direct and Intermediate Pathways for Streptococcic Invasion" with photomicrographs showing human middle-ear and mastoid involvement in which the infective organism did not follow the lines of continuity of infection, but was carried by the blood vessels and lymph channels in a manner confirmatory of the experimental researches in rabbits presented in a previous paper.

On the evening of December 4 a dinner was held in the Jansen Suite for members of the Society and invited guests.

The Eleventh Annual Meeting of the **Deutsche Gesellshaft für Unfallheilkunde, Versicherungs- und Versorgungsmedizin** was held in Hamburg on September 18 and 19, 1936, with Prof. Dr. M. zur Verth presiding.

The first of three chief topics taken up at this convention was "Hereditary Diseases and Insurance", to which the pathologist, Aschoff, contributed the concept of disease affecting biological existence through generations, laid stress on the value of the study of twins, and stated that arteriosclerosis was not inherited. Bauer of Breslau found 272 hereditary conditions of interest to the surgeon, among which he mentioned joint hyperextensibility, cleidocranial dysostosis, osteogenesis imperfecta, and "marble bones".

The second topic was "Meniscus Injury". Ceelen of Bonn gave an account of the non-traumatic degeneration of the semilunar cartilages and Buerkle de la Camp pointed out that a meniscus laceration occurring in an athlete usually heals spontaneously, but that in a miner such an injury rarely heals spontaneously, because the latter's injury usually follows long-continued or repeated trauma of lesser degree.

The third topic dealt with the influence of insurance on the course of disease. Erb of Halberstadt supported the prevailing contention that in accident cases the patients take advantage of their disability compensation to prolong their period of recovery. Gebhardt of Hohenlychen, however, felt that accident cases had been judged too harshly.

Other minor subjects of discussion brought out points of interest. König of Würzburg, in a statistical analysis of over 100,000 fractures, found that pseudarthrosis resulted in 0.48 per cent. of simple fractures and in 5.7 per cent. of compound fractures. Magnus of Munich pointed out the danger of occasional infection in skeletal traction and stated his preference for traction through the tibial tuberosity in fractures of the femur and through a point four fingerbreadths below the olecranon when applied to the elbow. Laarmann of Bochum regarded intracapsular injection of air or uroselectan to be harmless and valuable in the roentgenographic diagnosis of meniscus injuries. In lower-leg amputations, zur Verth emphasized the advantage of covering the stump with a long anterior flap instead of resorting to a long posterior flap, because the latter resulted often in chronic ulceration in the presence of healing by secondary intention. Zur Verth also demonstrated cases of amputation in which wooden prostheses had been of greater value than the leather artificial limb. Stier of Berlin spoke of head injuries which give rise to midbrain symptoms of pyrexia, insomnia, diabetes insipidus, etc. Junghanns of Frankfurt presented a case of localized thrombo-angiitis obliterans of the forearm occurring in a man who had worked for ten years with a compressed-air tool. Graf of Neumünster reported success in the treatment of anthrax with large intravenous doses of serum.

The First Congress of the Austrian Society of Roentgenology and Radiology was held in Vienna, September 4 to 8, 1936, under the chairmanship of Prof. R. Kienböck. There were three principal topics for discussion at this meeting:

1. The use of the x-ray in the study of organic function.

2. The technique of the serialograph: a study of clinical methods.
3. The therapeutic use of the x-ray: the principles of development and the biological considerations in the various methods of irradiation.

The selection of these important topics and the excellent organization of the Congress made it a meeting of international value.

The Congress was opened by the President of Austria, and Prof. L. Freund delivered the opening lecture, in which he considered the development of the use of the x-ray in diagnosis and therapy. He made a special point of the fact that x-ray irradiation was first practised in Vienna.

The three topics were considered at length by a large number of speakers, who discussed first symptomatology and the use of the x-ray in the study of the functions as well as the morphology of the various organs of the body, and showed to what extent efficiency in this use of x-ray has been developed in the last few years.

In connection with the second topic, that of x-ray serialography, the progress afforded in examination of organic function was considered. The advantages and disadvantages of the several serialographic methods were presented, illustrated by different types of films. This demonstration was opened by Dr. Dessauer of Istambul, who presented the development of the method.

The third topic was the methods of irradiation as practised at present. This discussion was opened by Dr. Schwarz of Vienna, who described the principles of development and the biological elements in roentgenotherapeutic irradiation.

The Congress was attended by roentgenologists from different parts of the world. The various addresses showed an appreciation of the use of the x-ray to demonstrate function as well as morphology, and by emphasizing the technical progress they gave an insight into the wider range of vital phenomena made possible by this new technique and indicated that further progress has been made in successfully combating carcinoma.

A memorial to the victims of the x-ray in Austria—Bosch, Czepa, Dautwitz, Dohan, Freud, Haudek, Holzknecht, Pordes, and Schönfeld—was presented at this meeting.

BRITISH ORTHOPAEDIC ASSOCIATION

The Annual Meeting of the British Orthopaedic Association was held in London on October 30 and 31 under the Presidency of Mr. W. R. Bristow. On both mornings at the Royal Society of Medicine, a series of short papers were presented as follows:

Sciatic Scoliosis by Mr. E. N. Wardle, Liverpool

The cases of twenty-six patients suffering from this complaint were reviewed. They fell into two groups,—those without and those with deformity. The majority of patients were in the latter group. Mr. Wardle suggested that diminution in the height of the intervertebral disc between the fifth lumbar and first sacral vertebrae might be of importance in determining the occurrence of pressure on the lumbosacral cord. In all of the patients, complete relief had followed prolonged immobilization of the spine in a plaster jacket applied in suspension.

The Nature and Significance of Protrusio Acetabuli by Mr. John Gilmour, Newcastle

The author contended that protrusio acetabuli commenced in early adolescence, and almost exclusively in the female sex about the time of menstruation. He argued that softening of the Y-shaped cartilage, due to some endocrine disturbance of ossification, resulted in a giving way before the pressure of the femoral head, with consequent increase in depth of the socket. He considered the condition analogous to separation of the upper femoral epiphysis in adolescence ("slipped epiphysis").

Arthrodesis of the Hip for Tuberculous Arthritis by Mr. H. J. Seddon, London

The cases of nineteen patients were reported on each of whom an extra-articular arthrodesis had been performed for healed tuberculous arthritis of the hip. At first, a tibial graft had been used, but the author expressed his preference for a broad full-thick-

ness iliac graft. Emphasis was laid on the advantages of operating through a large window in a previously applied plaster-of-Paris spica. Sound bony ankylosis had occurred in the large majority of patients, and the excellent functional results following the procedure were demonstrated by many of the patients in person.

Culture Methods as a Means of Diagnosis in Surgical Tuberculosis by Dr. Joseph Bamforth, London

Dr. Bamforth outlined the manner in which a high percentage of positive cultures could be obtained from fluids containing the tubercle bacilli—*e.g.*, pus, synovial fluid—on special media. The method has the advantages of reliability and the facilitation of early diagnosis, for a statement one way or the other can be supplied in from two to three weeks after incubation.

Skin Defects Limiting Joint Movement by Sir Harold Gillies, London

Sir Harold demonstrated many patients illustrating the advantages of different forms of skin grafts for contractures and skin defects around various joints. The resulting improvement in appearance and in function was striking. Particular interest was aroused by the case of a patient suffering from generalized oedema of both lower extremities, with extensive skin ulceration.

Chronic Backache by Mr. J. S. Batchelor, London

The cases of 116 patients were reviewed and these fell, in almost equal numbers, into two groups,—*mechanical* backache, due to faulty posture, etc., and backache due to *fibrositis* (acute or chronic, superficial or deep). Emphasis was laid on the frequency with which backache caused by mechanical strain is complicated by the occurrence of secondary fibrositis. Different regimens of treatment were advocated for each of the two groups. For the *mechanical strain* repeated manipulation without anaesthesia, followed by appropriate exercises, had proved more successful than routine manipulation under anaesthesia. *Acute* and subacute fibrositis demanded adequate rest and heat in the early stages, followed by graduated exercise and occasionally by a manipulation under anaesthesia to restore mobility. A manipulation under anaesthesia was usually necessary as a preliminary in the treatment of *chronic* fibrositis. Relief of symptoms had been achieved in almost all of the patients suffering from mechanical strains and in about two-thirds of those suffering from fibrositis.

Oedema of the Feet and Ankles Not Associated with Organic Disease by Dr. A. A. Osman, London

Dr. Osman regarded this condition as a local manifestation of a generalized metabolic disturbance clinically associated with general debility. In all of his patients he had found a lowering of the alkali reserves (acidosis). Hence he believed that the oedema was due to gravity acting in the presence of a water-logged "soil". The majority of his patients had been cured by appropriate periods of rest and by the administration of large doses of alkalis, usually in the form of potassium citrate (up to 1000 grains daily).

A Method of Insertion of the Smith-Petersen Pin by Mr. H. A. Brittain, Norwich

A consecutive series of twenty medial fractures of the neck of the femur were reviewed. They had all been treated by internal fixation after reduction with a Smith-Petersen nail, introduced over a calibrated central guide through a half-inch incision under roentgenographic control. It was claimed that the three main difficulties—the reduction of the fracture, the placing of the nail correctly both in the anteroposterior and in the lateral planes, and the selection of a nail of correct length—were more easily overcome by this method than by an open procedure. Mr. Brittain suggested that it was wise to place the nail near the inferior and posterior margins of the femoral neck, since this minimized the danger that the nail might break out of the capital fragment by adduction and external rotation of the limb, the position most frequently adopted by a patient resting in bed. Three deaths occurred,—one from a pulmonary embolus and two from causes unassociated with the injury. Of the remaining seventeen patients, union of the fragments occurred in all except two.

Principles of Treatment of Fractures by Mr. George Perkins, London

Mr. Perkins emphasized the fact that a fracture is a dual injury,—injury to the bone and injury to the soft parts. He made a strong plea that both should be treated concomitantly by encouraging from the very beginning active movement and use of those joints not immobilized by the necessary splintage.

Results of Treatment of Giant-Cell Tumors of the Long Bones by Mr. Roland Barnes, Manchester

A critical survey of thirty-eight giant-cell tumors, reviewed by the writer at the Memorial Hospital, New York, was presented. The best results in terms of non-recurrence and of joint function had been achieved by curettage and cauterization. Treatment by irradiation alone was not advisable, since it usually meant that histological proof of the nature of the tumor was lacking, that the cartilage of neighboring joints was extensively damaged, and that recurrences were a little more frequent. Complete excision of the tumor was an excellent procedure, though with a very limited field of application. Amputation remained as the treatment of choice in neglected tumors in the upper end of the tibia or in the lower end of the femur.

On the afternoon of October 30, at St. Thomas' Hospital, Mr. C. Max Page and Mr. George Perkins gave a demonstration of operations and showed a large number of patients illustrating end results. In the evening the Association Dinner was held at the Langham Hotel. Among the guests present were the President of the Royal College of Surgeons and Dr. Ralph Ghormley, Secretary of the American Orthopaedic Association.

At the October meeting of the Executive Committee of the **British Orthopaedic Association,** the following were elected to membership:

Full Member

Mr. A. Gillies, Wellington Hospital, Wellington, New Zealand.

Associate Members

Mr. W. G. Campbell, 316 Blackness Road, Dundee, Scotland.
Mr. J. A. Cholomeley, Royal National Orthopaedic Hospital, Stanmore, Middlesex.
Mr. F. S. Cooksey, 20 Oxford Terrace, Hyde Park, London, W. 2.
Mr. G. J. Lillie, Princess Elizabeth Orthopaedic Hospital, Buckerell Bore, Exeter.
Mr. H. F. Moseley, St. Thomas' Hospital, London, S. E. 1.
Mr. A. Quine, Ministry of Health, Whitehall, London.
Mr. D. W. Riley, c/o Dr. S. H. Scougall, B.M.A. Buildings, Macquarie Street, Sydney, Australia.
Mr. R. H. Young, 17 Park Crescent, London, W. 1.

At an earlier meeting of the Executive Committee, the following members were elected:

Full Member

Sir Morton Smart, K.C.V.O., 18 Grosvenor Square, London, W. 1.

Associate Members

Mr. J. S. Batchelor, Guy's Hospital, London, S. E. 1.
Mr. B. Keon Cohen, Robert Jones and Agnes Hunt Hospital, Oswestry, Shropshire.
Mr. W. D. Coltart, 81 Harley Street, London, W. 1.
Mr. D. C. Cranna, Robert Jones and Agnes Hunt Hospital, Oswestry, Shropshire.
Mr. W. Gray, Robert Jones and Agnes Hunt Hospital, Oswestry, Shropshire.
Mr. F. W. Holdsworth, 10 Southbourne Road, Sheffield 10, Yorkshire.
Mr. Geoffrey Hyman, 53 Cowper Street, Leeds.
Mr. A. L. Kenyon, 489 Blackburn Road, Oswaldtwistle, Lancashire.
Mr. G. K. McKee, St. Luke's Hospital, Lowestoft.
Mr. R. G. Pulvertaft, Robert Jones and Agnes Hunt Hospital, Oswestry, Shropshire.

AN ACKNOWLEDGMENT

In the July number of *The Journal* in his article entitled "The Therapeutic Active Principle of Maggots With a Description of Its Clinical Application in 567 Cases", Dr. S. K. Livingston quoted from a paper by Dr. Joseph Buchman published in *Annals of Surgery*, Volume XCIX, page 251, February 1934. This was not designated as a quotation and mention of the article was not given. In making this public apology to its readers and to the journals involved, *The Journal of Bone and Joint Surgery* expresses keen regret for this occurrence, and the author of the article is adding his explanation and apology.

Dr. Livingston's letter follows:

Box 162, Hines, Illinois
October 18, 1936

E. G. Brackett, Editor
The Journal of Bone and Joint Surgery
8 The Fenway
Boston, Massachusetts

Dear Sir:

Your letter of October 15 at hand relative to the similarity between an article published by me in July and an article published by Dr. Joseph Buchman entitled "The Rationale of the Treatment of Chronic Osteomyelitis with Special Reference to Maggot Therapy". I have reviewed the article by Dr. Buchman on this date and find his assertions are entirely correct. While I did not compile much of the material used in this paper, still, I of necessity must assume all responsibility for whatever appeared therein.

This paper, among several others, was compiled during the past year by one or more of three clerks, who are partially employed by me for reference work compilation and typing of texts. It is apparent that through an oversight Dr. Buchman's name and reference thereto was omitted.

I realize the grave injustice done Dr. Buchman and The Journal of Bone and Joint Surgery. I realize also that an omission of credit where credit is due is a serious, unlawful, and embarrassing situation. It is a situation, however, which occurred innocently without forethought of neglect toward Dr. Buchman or his work. Were this not the case, I think it must be evident to all of us that full credit would have been given, because it is simple and easy to give credit, and difficult to explain situations such as this, to say nothing of the ethics involved, which have been violated.

It is my wish to ask the forgiveness of Dr. Buchman and the forgiveness of The Journal of Bone and Joint Surgery for this omission. It is further my wish to correct publicly this error in a subsequent issue of The Journal.

I have made the above statements in fairness to all of us, and only through an oversight, and an apparently inefficient method of compiling information, could such a mistake have been made. I assure you that my method of editing will be radically changed.

Sincerely yours,

(Signed) *S. K. Livingston.*

Dr. Livingston also omitted reference to an article by Dr. Hyman I. Goldstein ("Maggots and Other Insects in Medicine—III" published in *Medical Review of Reviews*, Volume XXXVII, page 480, September 1931) in which he gave much interesting historical data in regard to the use of maggots, and made a statement in which he predicted or suggested that the trend of this therapy might develop along these lines. It is recognized that credit should have been given to Dr. Goldstein for his early suggestion of the trend of development. His priority of statement is hereby acknowledged, and *The Journal* regrets that this omission should have occurred.

Current Literature

Disability Evaluation. Principles of Treatment of Compensable Injuries. Earl D. McBride, B.S., M.D., F.A.C.S. Philadelphia and London, J. B. Lippincott Co., 1936. $8.00.

It is almost impossible for the human mind to cope with all the factors which must be taken into consideration in estimating disability, and Dr. McBride has courageously tackled a very intricate and intangible problem. He has, however, established a physical yardstick for measuring the actual mechanical factors which enter into the picture. In the first chapter, he has reviewed the compensation laws and called attention to the variations in these laws in different states, and continued the discussion from the standpoint of loss of earning capacity and economic and social needs of disabled workmen or their dependents.

Disability, especially that arising from fractures, is graded under the headings of anatomical results, functional results, and economic results, with further subdivisions into percentages (1 = 25 per cent.; 2 = 50 per cent.; 3 = 75 per cent.; 4 = 100 per cent.) and an actual arithmetical estimation. The chapter on examination of the various parts is brief; attention is called to the many disabilities of each part which may occur, thus refreshing the mind of the examiner on many points which might be overlooked and suggesting methods for the evaluation of such disabilities.

The line drawings are excellent. The illustrations showing workmen in various postures necessitated by their trade add to the clarity of the text and call attention to disability, so far as a particular occupation is concerned, which may occur as a result of quite minor injury to a certain part of the anatomy. The physics of locomotion and the effect of distorted anatomy on locomotion are well discussed and well illustrated.

In the treatment of fractures, McBride has covered the anatomy and part of the treatment to illustrate his own views on such treatment. While one may not always agree in the choice of methods, they are all reasonable and in his hands undoubtedly produce amazingly good results. The chapter on nerve injuries is mostly a review of the anatomy of the nervous system. The treatment of back injuries is one of the most difficult things to put into print, because of the complexities of the subject. Here it is handled intelligently and conservatively.

The book is well indexed and nicely printed, and it will arouse interest in a subject which has been much misunderstood and abused. This establishment of a reasonable working basis for an estimate of disability which occurs as a result of accident is an addition to surgical literature which the reviewer believes will be permanent. The next edition will correct some of the minor errors which have been made. All in all, this is an excellent book on a very difficult subject.

L'Ostéosynthèse au point de vue biologique. Influence de la nature du métal. Etude expérimentale. (Osteosynthesis. A Biological Study with Reference to the Effect of Metals.) G. Ménégaux et D. Odiette. Paris, Masson et Cie, 1936. 35 francs.

The authors have presented the results of their investigations on a subject which needs definite information, and this book should be of very distinct value to all who are interested in the problem of osteosynthesis. It represents the outcome of two years of laboratory investigation and study and of experimental work on animals.

The object of this study was to determine the toxic action of different metals which are used or which may be used in operations on bones. It is known that certain metals have at times a very distinctly toxic action, but the reason for this and the relative value

of different metals are not thoroughly understood. Experience has shown that, even under the most favorable conditions, fractures which are held by metal in good position often fail to unite, often show late and definite osteoporosis, and even at times recur. In this work the cellular changes accompanying the use of different metals are studied and also the results of the investigation of the problem on living subjects are recorded.

The subject has been studied from the mechanical, surgical, and biological points of view, and is treated under four heads: the general consideration of osteosynthesis; the results of investigations of the action of different types of metals on living tissues, as observed by cellular reactions; the results of experimentation on animals; and, finally, the practical results which have been obtained by this study.

In the first part of the book there is given an interesting history of the gradual development of the use of metals, with a discussion of the opinions of different authors and the comparative value of various metal substances which have been used. This is followed by a statement of the objects of the present study and the methods used by the authors.

Five series of experiments were carried out on cultures of tissues in which was observed the cytotoxic action of different metals and alloys on the fibroblasts and osteoblasts of hens, on human osteoblasts, on cultivated osteoblasts (*en vie ralentie*), and on the repair of loss of substance. The control experiments were carried out on animals in two series. The action of the metals on living bone was studied in three series: in one the metal was placed subperiosteally; in another, within the substance of the bone; and in the third the plates and screws were fixed firmly to the bones. It was found that the results obtained were practically identical.

The authors then give the general results of their experiments in which they demonstrate the toxic effect of certain metals and the relative non-toxicity of others. They divide their report on these metals into three groups: first, those metals which are distinctly toxic; second, those which are less toxic; and, third, those which have been found to be quite non-toxic, including their alloys.

This book gives very definite and practical information which, considering the present state of our knowledge of this subject and the large amount of bone work being done, is indeed timely.

Behandlung der Verletzungen und Eiterungen an Fingern und Hand (The Treatment of Injuries and Infections of the Fingers and Hand). Prof. Dr. M. zur Verth. 2 Aufl. Berlin, Julius Springer, 1936. 9.60 marks.

This book attacks the subject of surgical affections of the fingers and hand directly and fundamentally. In addition to presenting an excellent study of fractures, it deals with tissue-destructive injuries which are incipiently clean and with injuries whose first evidence is that of bacterial infection. The book contains fifty-nine significant illustrations and the form of printing allows much to be contained in its 164 pages.

The topics are presented on a clear anatomical basis, and treatment is determined by the architecture of the hand, by the resistance of tissue to infection, and by the relative importance of various structures for function. The book is devoted to the application of principles. Years of experience with great numbers of accident insurance cases enable the author to establish lines of treatment which are supported by statistical proof. Acknowledgment is made to Kanavel in the discussion of suppuration of tendon sheaths and of palmar spaces and to Böhler in the treatment of fractures.

Great emphasis is laid on the prompt excision of potentially infected or necrotic tissue in an open wound. Injuries and infections heal most rapidly with immobilization. Fingers are best immobilized by a flexible wire splint imbedded in a short forearm cast.

It is hardly fair to such a masterful presentation to cite from it a few examples of definite measures of treatment. The thoroughness with which fractures of the fingers, hand, and wrist are taken up makes comment on any one feature difficult. For those

who justly have high regard for the work of Kanavel on infections of the hand and for the principles of Böhler in the treatment of fractures and other injuries, this book will provide an eminent contribution to surgical literature.

ANATOMY OF THE HUMAN BODY. Henry Gray, F.R.S. Ed. 23. Revised and Re-edited by Warren H. Lewis, B.S., M.D. Philadelphia, Lea & Febiger, 1936. $10.00.

This twenty-third edition is testimony to the continued excellence of this work which was first edited by Henry Gray in 1858. Starting with a volume of 750 pages and 350 illustrations, its growth through twenty-three editions to the present one of 1380 pages with 1216 engravings is evidence of the appreciation of this work by the medical public. That the present editor has retained the general plan of presentation of much of the original text and many of the illustrations is also evidence of the quality of the original work. Many of those who first learned their anatomy from the early editions will welcome with satisfaction these familiar descriptions and the illustrations which compare so favorably with the more recent cuts, in spite of the new and improved methods of reproduction.

Much knowledge has been gained in recent years and has enlarged the original work of the anatomists. Especially is this true as regards the subject of microscopic anatomy. This edition has dealt very generously with the new knowledge, and the insertion of this new material has resulted in an enlargement of the scope as well as the size of the volume.

The editor has given to the readers the present status of information in a clear and definitely organized plan. The comprehensiveness of this book is evidenced by the divisions under which the subject is presented: Embryology, Osteology, Syndesmology, Myology, The Blood-Vascular System, The Arteries, The Veins, The Lymphatic System, Neurology, The Organs of the Senses, The Common Integument, Splanchnology, Surface Anatomy and Surface Markings.

In an anatomy of this sort the illustrations must necessarily form an essential supplement to the text, even if they are not of equal value. This requirement will be found to have been satisfactorily fulfilled in this edition. More color has been added to differentiate the various structures in the illustrations of the regional anatomy, which makes clearer the relationship between the different parts.

The use of B. N. A. nomenclature in English has been retained, except for the adoption of the Langley terminology for the autonomic nervous system, but the other nomenclature is given parenthetically, which avoids difficulty or confusion to those who are more familiar with the older terminology. This edition will add another period to the already long life of Gray's *Anatomy*.

DIE PYOGENE ALLGEMEININFEKTION UND IHRE BEHANDLUNG (Generalized Pyogenic Infection and Its Treatment). Prof. Dr. Erich Lexer. 2 Aufl. (Vorträge aus der praktischen Chirurgie, 1 Heft.) Stuttgart, Ferdinand Enke, 1936. 1.60 marks.

Lexer defines the generalized pyogenic infection as the general effect upon the entire body by localized pyogenic processes, with and without metastases. The metastatic form may be purely bacterial or thrombo-embolic; the form without metastases he defines as a pyogenic infection of the blood of either toxic or bacterial form, although a toxic element is provided also by the latter. The author attempts to circumvent such indefinite terms as "sepsis" and "pyemia".

The second portion of the lecture is concerned with bacterial resorption and spread, local tissue reaction, blood-stream destruction, and reticulo-endothelial phagocytosis and resistance as lines of defense. Schulze's experiments are mentioned to show that favorable points of attack for bacteria are furnished by organs where the capillaries are wide and the blood stream is slowed, but nature provides that these organs are important parts of the reticulo-endothelial system,—liver, spleen, bone marrow, and lymph nodes.

The clinical stages of the spread of an infection to the final picture of shock with circulatory failure are well described, with emphasis on the fact that treatment instituted after shock has set in is of little avail.

The first and most important part of treatment of the general infection is the thorough exposure of its localized sources, even to the extent of amputation of an extremity, with subsequent protection and gentle handling of the wound surfaces. In the treatment of the general infection, occasional surprisingly good results have been obtained from immune serum produced in individuals by an autogenous vaccine.

If bacteriophage is used, it should be tested previously to determine its specific effect *in vitro* upon the isolated and cultured strain of bacterium responsible for the infection.

Another method of attack is the direct stimulation of the reticulo-endothelial defense mechanism, if its resistance has not already been too impaired. Colloidal silver is probably without value. Of foreign proteins, only splenic extract has shown a striking effect in animal experiments. The usefulness of producing a sterile abscess is not yet proved. Repeated blood transfusions of 150 to 200 cubic centimeters may be of help, particularly if they come from an individual recently recovered from the same infection for which the patient is being treated. Radiation of the entire body, especially of the spleen and of the long bones, or short-wave radiation of the spleen is still of questionable value.

Jentzer pursues a course of treatment in which (1) a leukocytic response is secured by the intravenous administration of alcohol extracts of pine needles, camphor and cinnamon, with phenol, thymol, and a resin addition (proprietary preparation in 0.6 c.c. ampules under the name of "Themsalin"), and (2) bactericidal antigens are formed by the subcutaneous injection of a mixture of turpentine-free oils and lipoids.

Circulatory collapse may be combated with camphor, caffein, and adrenalin preparations, but the most important means of stimulation is the intravenous administration of 0.5 to 0.75 of a milligram of strophanthin.

REPORTS ON CHRONIC RHEUMATIC DISEASES. BEING THE ANNUAL REPORT OF THE BRITISH COMMITTEE ON CHRONIC RHEUMATIC DISEASES APPOINTED BY THE ROYAL COLLEGE OF PHYSICIANS. Volumes I and II. Edited by C. W. Buckley, M.D., F.R.C.P. New York, The Macmillan Company, 1936. Vol. I, $4.00; Vol. II, $3.50.

Two Annual Reports have been published by the British Committee on Chronic Rheumatic Diseases, appointed by the Royal College of Physicians. The two volumes embody the results of recent observations and studies of chronic rheumatic diseases by many workers. The literature has been carefully and critically reviewed by experts in these subjects. The chapter on nomenclature is of especial interest and value as it expresses the British thought about classification and is also approved by the American Committee. Allergy, focal infection, pathology, orthopaedic treatment, and biochemical studies are discussed in condensed "critical comments". The volume is a storehouse of valuable information for all students of arthritis. Each discussion is simple and thought-provoking.

The second volume is more specific in its review of the present beliefs regarding "chronic infective arthritis", particularly the rôle played by tuberculosis and by the hemolytic streptococcus in rheumatoid (atrophic) arthritis. Clinical and laboratory research of real value is presented in an available way. Even the psychological aspects are discussed.

As the Committee states, all the subjects related to the study and treatment of chronic rheumatic diseases cannot be included in these two volumes, but they are a beginning and are of real value. The comments of experts are always important, not only for the specialist but for the general practitioner. In these reports is also a wealth of bibliographic material, carefully selected. These volumes are, therefore, a valuable contribution to a difficult subject and well worth reading.

A PREFACE TO NERVOUS DISEASE. Stanley Cobb, A.B., M.D. Baltimore, William Wood & Co., 1936. $2.50.

This small book of some 170 pages should be read by every orthopaedic surgeon and then placed in his library for convenient reference. The diction is delightful: scientific enough to be dignified, simple enough to be understandable by every intelligent medical man. No verbiage is to be found; graphic summaries follow necessarily extensive discussions. The book is full of etiological, diagnostic, and therapeutic information, of explanation, and of original and convincing thought.

Chapter III, on "Motor Integration and Locomotion", will aid orthopaedic surgeons to solve many of their most perplexing problems. The boundaries of neurology and orthopaedic surgery are often contiguous and there should be free interchange of those commodities of knowledge which both specialties either have acquired or may discover.

The line drawings and tables with which the text is interspersed add greatly to the reference value of the book. The author's familiarity with old and new neurological literature and research is evident and the last sentence bespeaks a refreshing enthusiasm for his subject: "There is a great future just ahead in this branch of medicine."

We warmly recommend to all general practitioners and specialists in other fields of medicine and surgery "A Preface to Nervous Disease".

ALLGEMEINE GEGENANZEIGEN BEI NICHT DRINGLICHEN CHIRURGISCHEN EINGRIFFEN (General Contra-Indications in Elective Surgical Operations). Prof. Dr. P. Clairmont und Dr. W. Brunner. (Vorträge aus der praktischen Chirurgie, 10 Heft.) Stuttgart, Ferdinand Enke, 1936. 4.20 marks.

This monograph of sixty-six pages is based on numerous publications dealing with fatal postoperative complications, and the authors warn against elective operation in any case in which the patient's condition is liable to precipitate such a postoperative complication.

Operative trauma expresses itself in five ways: (1) impaired cardiovascular function; (2) deficient pulmonary ventilation during and after operation; (3) increased excretory burden by diminished alkali reserve, by chloride loss, and by increased catabolism of protein, fat, and carbohydrate; (4) leukocytosis and increased plasma viscosity; and (5) the so called postoperative symptom complex or shock of peripheral vascular type.

The chief source of contra-indication is the cardiovascular system. The authors regard the simplest and most reliable test of latent cardiac insufficiency to be a tachycardia of 160 on stair-climbing.

Postoperative complications of the lungs and of the respiratory passages cause 25 per cent. of the deaths following operation. Maintenance of the normal acid-base balance by adequate exchange of oxygen and carbon dioxide represents respiratory sufficiency. Active infection of the lungs or of the upper respiratory passages is definite contra-indication to operation. Chronic bronchitis on the basis of emphysema and of bronchiectasis presents a great risk.

Judgment of liver function is difficult. The most sensitive indication of impaired hepatic function is an abnormally increased urobilinaemia. Although any condition which produces a distinct rise in serum globulin will give a positive Takata-Ara reaction, the authors found it to be positive usually in cirrhosis, but also in fatty infiltration and carcinoma of the liver.

Renal function is measured by the familiar tests,—dilution and concentration, and excretion of indigo carmine and phenolsulphonphthalein. Only severe renal damage increases blood non-protein nitrogen and indican. Increased blood protein, determined by the xanthoproteic test, shows severe renal damage in the presence of increased blood indican; otherwise, it is a sign of hepatic insufficiency.

With respect to the hematopoietic system, if both serum globulin and speed of erythrocyte sedimentation are increased, an elective operation should not be performed without determination of the cause of this increase. Aplastic anaemia, refractive both

to iron and to liver therapy, presents an absolute contra-indication. When the primary indication for operation contributes to the anaemia, the importance of the operation itself is greater. Operation on a leukemic patient is permissible with an erythrocyte count of 4,000,000 and a hemoglobin of 80 per cent. A symptomatic thrombopenia with a platelet count of 20,000 to 30,000 provides a poor risk. Essential thrombopenia demands splenectomy. Affections of the spleen are to be judged by the degree of the associated anaemia.

In conditions of disturbed protein metabolism, care must be exercised when gout or amyloidosis is present. In diabetes, ketonaemia or acidosis, or both, represent serious contra-indication. Each diabetic should be controlled by diet and insulin before operation. In the Zurich Clinic, the blood-sugar curve must be maintained at a constant level with a maximum of 160 milligrams per 100 cubic centimeters with absent glycosuria and acetonuria; the alkali reserve should be as nearly normal as possible.

Under the endocrine dyscrasias, hyperthyroidism presents a frequent danger, particularly as a latent hyperthyroidism may be brought to light by operation. Defective states of heart and peripheral circulation should always raise a suspicion of hyperthyroidism. Tetany with a blood calcium below 9 milligrams per 100 cubic centimeters contra-indicates operation. Of hypophysial disorders, the greatest operative danger lies in hypophysial basophilism (Cushing) and in Simmonds' disease.

With respect to age, one finds the minimum resistance to trauma at birth (although Ombrédanne asserts that up to four days of age the infant is as resistant as the adult!) and the greatest at the age of fifteen.

Susceptibility to infection and to trauma is increased during menstruation.

In connection with coexistent generalized infection, primary and secondary lues should receive three weeks of specific treatment before an operation.

Nervous disorders must be regarded.

Indication within the field of operation itself is also open to debate. Total thyroidectomy for cardiac decompensation and angina pectoris has been too extensively performed. The indications for sympathectomy probably require limitation.

The most important guide to elective as well as to emergency operations is an exact diagnosis, together with the conviction that the operation will relieve or alleviate an affection to a greater extent than medical treatment or radiation therapy.

A TEXTBOOK OF SURGERY. John Homans, M.D. Ed. 4. Springfield, Illinois, and Baltimore, Maryland, Charles C. Thomas, 1936. $8.00.

This book is compiled from lectures and other writings of the following members of the Surgical Department of the Harvard Medical School: Arthur W. Allen, David Cheever, Edward D. Churchill, Harvey Cushing, William P. Graves, Robert B. Greenough, John Homans, Gilbert Horrax, Daniel Fiske Jones, William E. Ladd, George A. Leland, Howard A. Lothrop, Richard H. Miller, Edward H. Nichols, Robert B. Osgood, Charles Allen Porter, Tracy J. Putnam, Lyman G. Richards, Edward P. Richardson, Channing C. Simmons, J. Herbert Waite, Wyman Whittemore, and Philip D. Wilson.

In this fourth edition new chapters on "Amputations" and "Plastic Surgery" have been added to round out a text-book which otherwise adequately covered general surgery.

The make-up of the book is better than was that of the first edition, for the whiter paper used sets off the black line drawings more clearly.

Since this is a text-book for medical students, one would expect it to give a little information on practically every surgical subject, without exhaustive treatises on any one subject. The book does just this and does it well.

BONES: A STUDY OF THE DEVELOPMENT AND STRUCTURE OF THE VERTEBRATE SKELETON. P. D. F. Murray, M.A., D.S.C. Cambridge, England, University Press; New York, The Macmillan Company; 1936. $2.50.

This monograph presents a study of the development and structure of the vertebrate skeleton based on operative, embryonic experiments chiefly on the chick and on the

rabbit. In the first two chapters the author discusses the development of bone replacement,—first, in the preparation of the cartilaginous model; and, second, in the development of the bony structure for which it provides a scaffold. He finds that cartilage is not developed out of undifferentiated mesenchymal cells but from mesenchymal cells which are predestined for such development. Similarly the ossification of the cartilaginous skeleton follows certain predestined patterns, extensively modified, however, by external conditions of growth and of pressure. Such conditions affect not only the shape of the skull and of such bones as the calcaneum but also the internal architecture of bone.

Chapter III considers in further detail these functional changes in the forms of bones and of joints, and Chapter IV discusses and compares the trajectorial theory of bone architecture with Treipel's theory of harmonic adaptation in which muscular stresses are regarded as more important than the mechanical stresses of weight-bearing.

Chapter V discusses similar problems with relation to the mechanical structure of the cartilage and the arrangement of cartilage cells, and Chapter VI presents the mechanism of bony adaptation.

Like all works of research, this book is necessarily incomplete; but it is extremely well written and illustrated, presents a lucid exposition of difficult embryological and morphological problems, and points out probable fruitful directions which further research upon these problems may advantageously take.

A Health Education Workbook for Teachers, Parents, Nurses, and Social Workers. Kathleen Wilkinson Wootten, M.A. New York, A. S. Barnes & Co., Inc., 1936. $1.50.

Miss Wootten dedicates the book to the 10,000 girls of Georgia State College for Women where she has been Professor of Health and head of the Health and Physical Education Department for the past ten years.

The introduction tells of the purpose of the book, sets forth the practical aims of health education, and gives a list of the various organizations which have supported the modern health education program.

This book incorporates such topics as the necessary training and qualifications of the teacher of health and the parents' share in the health program of the child. The teacher's responsibility for the health of the school child is divided into sections,—mental hygiene, speech defects, sex education, posture, etc.

Remediable defects of school children are considered with reference to symptoms, results, causes, method of examination, and the remedies for these defects.

An outline of study is presented, which includes primary, intermediate, and secondary-school health education, along with activities, objectives, and evaluations.

This book is to be recommended to those who are interested in the health education of children, also to those who include this phase of work in their professions.

Leitfaden der Massage (Guides for Massage). Dr. Max Böhm. 6 Aufl. Stuttgart, Ferdinand Enke, 1936. 3.50 marks.

In this sixth edition of "Leitfaden der Massage", Dr. Böhm has given to the medical profession and to those who are engaged in this special therapy, the results of his further experience in this field. In addition to his other medical and surgical interests, Dr. Böhm has always paid particular attention to this form of treatment, especially in its adaptation to the different conditions to which it could be applied. His discussion of the more important details of the methods of application and of the types to be employed in the different pathological and traumatological conditions will be found very helpful by those who have occasion to use this special method of treatment. It is indeed fortunate that Dr. Böhm was able to give to the medical profession the results of his more mature experience before his untimely death.

MEDICAL CLASSICS. Compiled by Emerson Crosby Kelly, M.D. Vol. 1, No. 1, Sept. 1936. Baltimore, The Williams & Wilkins Company.

The object of this publication is to revive interest in the history of medicine and in the medical men who have been the high lights in the past. Its purpose is to recall the contributions which these men have made by republishing those works which have made them famous and which show what they have accomplished for medical advancement.

The first number is devoted to Sir James Paget, with a sketch of his life, a list of his voluminous writings, and the eponyms which have come from his special contributions. The original essay on the disease which bears his name is reproduced without change and with the original illustrations.

Other famous men in the history of medicine are to be considered in forthcoming numbers, and all students of medical history will welcome this new publication.

DER ANGEBORENE KLUMPFUSS (Congenital Club Foot). Dr. Med. Hans Debrunner. (Deutsche Orthopädie. Herausgegeben von Hermann Gocht in Berlin. 10. Band.) Stuttgart, Ferdinand Enke, 1936. 20 marks.

Another monograph on club-foot introduces little that is new, but combines the recent concepts of etiology and pathology with an adequate historical review in one volume of 130 pages. Excellent chapters on anatomy, physiology, and etiology are illustrated by rather primitive line drawings. Eugenic prevention of congenital deformities is suggested; sterilization is mentioned, but is not advocated.

The treatment offered is that of Gocht, the writer's teacher and editor of *Deutsche Orthopädie*, to whom the volume is dedicated. Early treatment is urged. In the late treatment the use of osteoclasts is emphasized, but all of the available procedures are classified and discussed.

Introduced as a text-book, the volume will find more favor as a reference work, particularly for those who are interested in the hereditary and developmental aspects.

The *Journal* wishes to acknowledge the receipt of the following publications sent to the Editorial Department:

Anales. Revista mensual de Medicina, Cirugía y Especialidades (Valencia), III, Núms. 29 and 30, 1936.
Anales de Cirugía (Rosario), II, No. 3, 1936.
Archives Franco-Belges de Chirurgie, XXXV, Nos. 3 and 4, 1936.
Boletines de la Sociedad de Cirugía de Rosario, III, Nos. 4, 5, and 6, 1936.
Bulletin of the National Tuberculosis Association, XXII, Nos. 10-12, 1936.
The Child (Washington, D. C.), I, Nos. 3-5, 1936.
Cirugìa Ortopédica y Traumatología (Madrid), I, Núms. 1 and 2, 1936.
Cleveland Clinic Quarterly, III, No. 4, 1936.
Conférences d'Orthopédie et de Chirurgie Infantile. Barboza Vianna. Rio de Janeiro, Est. Graf. Muniz, 1936.
Nutritive and Therapeutic Values of the Banana. A Digest of Scientific Literature. Boston, The United Fruit Company, 1936.
Radiography and Clinical Photography (Rochester, N. Y.), XII, No. 3, 1936.
University of Chicago, The Medical Schools, Announcements for the Sessions of 1936-1937. Chicago, 1936.

ÜBER TUBERKULÖSE SPONDYLITIS BEI FÄLLEN VON KYPHOSIS DORSALIS JUVENILIS SIVE ADOLESCENTIUM (Spine Tuberculosis in Cases of Kyphosis Dorsalis Juvenilis). Robert Hanson. *Acta Chirurgica Scandinavica*, LXXVIII, 297, 1936.

For nine pages the writer debates his priority over Schmorl in the presentation of certain findings, and the fallacy of Schmorl's theory as to the etiology of juvenile kyphosis. Seven cases are reported in detail in which vertebral tuberculosis was coincident with Scheuermann's disease.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

Zwei Fälle von Epiphysenlösung der Crista iliaca (Two Cases of Avulsion of the Epiphysis of the Crest of the Ilium). Gunnar Wiberg. *Acta Chirurgica Scandinavica*, LXXVIII, 329, 1936.

After reviewing the development of the pelvic osseous centers, the writer presents two cases in which a secondary epiphysis of the ilium was torn off by the indirect violence of unusually strenuous muscular effort. With strapping and bed rest the lesions healed enough to allow walking in a month.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

Notes on the Genesis of Giant-Cell Tumours. Hilding Bergstrand. *The American Journal of Cancer*, XXVII, 701, Aug. 1936.

The author presents a brief review of the literature dealing with the histogenesis of giant-cell tumors. She concludes that we do not know the genesis of solitary giant-cell tumors, but, on the basis of their similarity to the giant-cell tumors in osteitis fibrosa generalisata, they may well be regarded as due to local bone resorption. Certain observations favor the assumption that the primary cause of the resorption is a disturbed circulation. When the lime salts and collagen fibrils are resorbed the original bone-forming syncytium dedifferentiates, with a tendency to proliferation. The giant cells are not osteoclasts but unmasked bone corpuscles. Later regressive changes take place in the tumor, resulting finally in a bone cyst.

Giant-cell tumors are thus neither inflammatory nor neoplastic growths.

Some photomicrographs are presented in support of the theory.—*Grantley W. Taylor, M.D., Boston, Massachusetts.*

The Punch Biopsy in the Diagnosis of Tuberculosis of the Knee Joint. Michael Burman, Harry Finkelstein, and Leo Mayer. *American Review of Tuberculosis*, XXXIV, 663, Nov. 1936.

With a punch-biopsy instrument, specimens for biopsy were obtained from suspected joints by inserting the punch through the same puncture wound as that used for arthroscopy. The one undesirable feature is the fact that one is unable to remove the specimen under direct view, although theoretically this should be possible. However, the jaws of the instrument can be guided to a particular region, so that this difficulty is of slight importance.

Where it is impossible to obtain consent for biopsy, culture of saline washings from the joints has been made. Dr. Walter Galland, to whom credit for this method is given, instils saline into the joint, leaves the instilation in for a few minutes, and then removes and uses such washings for culture and guinea-pig inoculation. The results are good.—*Clarence A. Ryan, M.D., C.M., Vancouver, British Columbia.*

Dislocation and Elongation of the Long Head of the Biceps Brachii. An Analysis of Six Cases. Edgar Lorrington Gilcreest. *Annals of Surgery*, CIV, 118, July 1936.

When the tendon slips from its groove over the lesser tuberosity the tension of the biceps is lessened and the tendon becomes relaxed, producing the classical bicipital syndrome. The dislocation may be acute, recurrent, or gradual; in the first two types the disability is rapidly disabling. The mechanism of production is brought about by force applied by the arm in external rotation and abduction of 90 degrees or more. The tendon may be palpated outside the groove, or the empty groove may be demonstrated.

In recurrent dislocation one can at times reproduce the dislocation by having the patient hold a five-pound weight in the hand with the arm in overhead extension and external reduction. As the arm is adducted, the examiner feels with his fingers a definite snap at the top of the shoulder and along the belly of the biceps as 110 to 90 degrees of abduction is reached, and the patient experiences a sharp pain in the region of the bicipital groove.

Reduction may frequently be accomplished early by flexion at the elbow to 90 degrees, with the hand in supination; the arm is then abducted to 90 degrees in the coronal plane in internal rotation.

If the patient is seen late, or if there is a recurrence, open operation is recommended, with high severance of the tendon and suture to the coracoid process and to the tendon of the short head.

There is an anatomical consideration, an extensive bibliography, and an appendix. Six cases are analyzed.—*N. T. Kirk, M.D., San Francisco, California.*

SUPPURATIVE ARTHRITIS OF THE SACRO-ILIAC JOINT. Joseph B. L'Episcopo. *Annals of Surgery*, CIV, 289, Aug. 1936.

As in other pyogenic joint infections, a blood-borne infection may involve the sacro-iliac joint primarily or this joint may be involved secondarily from a primary focus in the ilium or sacrum adjacent to the joint.

The patient appears acutely ill with a temperature of from 100 to 104 degrees, a rapid pulse, and leukocytosis with an increase in polymorphonuclear neutrophiles. Pain is present in the buttock, in the hip area or over the sacro-iliac joint, and in the lower right or left abdominal quadrant. There is definite tenderness on pressure and percussion over the sacro-iliac joint. In the early stages, the roentgenogram is negative; after three weeks, definite destruction can be demonstrated.

Pus under pressure in the joint follows the path of least resistance; it quickly breaks through the thin anterior sacro-iliac ligament, burrows under the iliacus muscle, and fills the iliac fossa.

Treatment consists of early drainage through the sacro-iliac joint by resecting a block of the ilium over the joint and that part of the sacrum forming the joint, thus permitting the admission of two fingers into the pelvis. The iliac muscle is lifted from behind. Free pus is usually not found until the pelvic cavity is entered. The wound is packed with vaselin gauze and a plaster-of-Paris spica is applied.

Five cases are reported in detail.—*N. T. Kirk, M.D., San Francisco, California.*

RELIEF OF PAIN BY PERIPHERAL NERVE BLOCK IN ARTERIAL DISEASES OF THE LOWER EXTREMITIES. Beverly C. Smith. *Annals of Surgery*, CIV, 934, Nov. 1936.

Forty-six cases of ulceration and gangrene in the lower extremities, caused by occlusive arterial disease, which were treated by nerve block during a five-year period, are reported. The chief indication for treatment is the relief of pain. In this series an increase in local temperature to a varying degree occurred in cases of thrombo-angiitis. Major amputations were reduced to 48 per cent., the greatest number being necessary in the arteriosclerotic diabetic group.

Nerve block was performed by exposing the nerves in the leg under local anaesthesia, well above open lesions, by injection of alcohol and crushing, division, division and sutures, or by crushing two to six millimeters of the nerve.

The nerve supply to the foot is described in detail as well as the surgical anatomy of each nerve and the operative procedure to accomplish its block.—*N. T. Kirk, M.D., San Francisco, California.*

NERVE INJURY IN FRACTURE OF THE PELVIS. Conrad R. Lam. *Annals of Surgery*, CIV, 945, Nov. 1936.

Six of eighteen patients with fracture of the pelvis, treated at the Henry Ford Hospital during a recent one-year period, presented definite evidence of nerve injury. This experience prompted a study of 100 consecutive cases which showed that a nerve injury was present in 9 per cent. of the cases, as compared to fourteen cases or 0.74 per cent. of 1,889 cases collected from the English and German literature during the past twenty years.

The nerves involved in the nine cases were as follows: the peroneal component of the sciatic nerve, six cases; the lateral cutaneous femoral nerve, three cases (bilateral in one case); the superior gluteal nerve, one case; and the posterior branches of the first three sacral nerves, one case.

The preponderance of sensory over motor disturbance, the tardy appearance of symptoms, and the spontaneous regeneration, suggest that the trauma is in the form of stretch or contusion of the nerves.

Case reports of the nine cases are presented together with a bibliographic table showing the incidence of nerve injury in the reported series of cases.—*N. T. Kirk, M.D., San Francisco, California.*

Über die Fensterung der Gelenkkapsel (Fenestration of the Joint Capsule). Joh. Volkmann. *Archiv für orthopädische und Unfall-Chirurgie*, XXXVI, 509, 1936.

Chronic effusion into joints after trauma, operation, arthritis, etc., has been treated in recent years more and more by the so called window operation. There are three ways to perform this:

1. Small incision at the inner upper section, sharp or blunt dissection of the muscles, opening of the capsule, evacuation of the fluid, excision of a piece of the capsule the size of a quarter, which can be used for microscopic examination, closure by sutures of the fascia, muscles, and skin. This can be done under local anaesthesia.
2. Introduction of a large trocar and punching out of a piece of the capsule. By this procedure the danger of an open joint operation is eliminated.
3. Excision of a piece of the capsule to establish a window and closure of the musculature and skin over it. Mandl does not close entirely the joint capsule, and Klapp and Laewen do not sew the joint capsule at all, only the layers over it.

All three methods have the same purpose,—namely, to establish drainage of the joint effusion into the subdermal tissue. The author collected 151 cases from the literature in which this window operation had been performed,—forty-eight by Method 1, twenty by Method 2, and eighty-three by Method 3. The results were as follows:

Method	*Excellent* (*Per Cent.*)	*Fair* (*Per Cent.*)	*Failure* (*Per Cent.*)
1	70.8	6.3	22.9
2	50.0	30.0	20.0
3	71.0	19.3	9.7

In addition, the author describes seven cases of his own in which Method 1 had been performed after chronic synovitis, osteochondritis dissecans, and internal derangements of the knee joint,—all with recurrent joint effusions. In each case perfect restitution was obtained.—*Joseph Wolf, M.D., Iowa City, Iowa.*

Le cifosi dell' adolescenza (Kyphosis in Adolescence). Andrea Albanese. *Archivio di Ortopedia*, LII, 189, 1936.

After a historical review of the subject with an analysis of the more recent work on pathogenesis of the adolescent kyphosis (Scheuermann, Mau, Schmorl), the clinical and roentgenographic picture of the deformity is presented, based upon the study of 150 cases from the Orthopaedic Clinic in Milan.

Albanese subdivides his material into four groups according to pathology: (1) fibro-elastic; (2) osseous; (3) osteochondral; and (4) spondylo-arthral. All these different forms arise and develop in adolescence and may, therefore, be called juvenile or adolescent kyphosis, but each group is characterized by different pathogenic factors, of which part are well known and part are still obscure. For instance, the fibro-elastic type shows certain constitutional signs with weakness of the musculoligamentous apparatus; the osseous form is usually due to some malacic bone disease often of endocrine nature, especially

combined with pituitary dysfunction; the osteochondral form shows changes of enchondral ossification of the vertebral bodies; the changes of the intervertebral discs described by Schmorl may be concomitant (they are frequently found in normal cases) or they are secondary; the spondylo-arthral type represents a form of juvenile deforming spondylosis of obscure origin.—*Ernst Freund, M.D., Venice, Florida.*

SULLE MALFORMAZIONI CONGENITE DEL PERONE (Congenital Deformities of the Fibula). Rosario Marziani. *Archivio di Ortopedia*, LII, 281, 1936.

This relatively frequent congenital deformity is considered from two angles: (1) *defects in shape*, mainly consisting in a backward displacement of the distal end, resulting in absence of the outer malleolus; and (2) *defects in volume*—there may be general hypoplasia, localized at either the upper or the lower end, or hypoplasia may be absent. Eight cases, illustrating these different forms, are reported. Etiologically, external factors such as amniotic adhesions do not seem to be of importance: the deformity is due rather to a *vitium primae formationis*, sometimes comparable to one of the developmental forms of mutation.—*Ernst Freund, M.D., Venice, Florida.*

CONTRIBUTO AL TRATTAMENTO OPERATORIO DELLA INSUFFICIENZA PARALITICA DEL MEDIO E PICCOLO GLUTEO (Contribution to the Surgical Treatment of Paralysis of the Gluteus Medius and the Gluteus Minimus). Poli Antonio. *Archivio di Ortopedia*, LII, 307, 1936.

The different operative methods to improve abductor insufficiency are discussed. A new method is described which has been tried in three cases, apparently with satisfactory results. The method consists in the transplantation of the tensor fasciae latae and of the upper portion of the gluteus maximus to the greater trochanter, and of the vastus lateralis to the iliotibial band above the greater trochanter. The details of this operative method are accurately described.

Under general anaesthesia, a curved incision is made from the anterior superior to the posterior superior iliac spine and then down and below the greater trochanter. The tensor fasciae latae is freed at its anterior margin and severed at its insertion into the fascia. Then the upper portion of the gluteus maximus is separated from the lower portion along a line from the posterior superior iliac spine to the base of the greater trochanter. Full division of the muscle is safe only in the upper part; in the lower, one has to watch out for the inferior gluteal vessels and, especially, for the nerve. The muscle is cut at its insertion into the fascia lata. The distal ends of both muscles are firmly anchored under a bony periosteal flap of the outer surface of the greater trochanter. The vastus lateralis is used only to reenforce the action of the two transplanted muscles. Its proximal fibers are isolated from the femur down to the width of about three or four fingers and are sutured to the supratrochanteric portion of the iliotibial band, previously cut transversely. The leg is kept in abduction of about 30 degrees and the transplanted muscles are fastened under tension. Immobilization in a hip spica cast is maintained for two months.—*Ernst Freund, M.D., Venice, Florida.*

INTERVENTO CHIRURGICO NELLA PARALISI OSTETRICA (Surgical Intervention in Birth Palsy). Mario Peracino. *Archivio di Ortopedia*, LII, 321, 1936.

The author reports five cases with sequelae of birth palsy of four to nineteen years' duration. In two of the cases the lesions were in the upper arm; in three also the forearm and hand were involved. Operative intervention aims mainly at correction of the internal rotation of the humerus, of the pronation of the forearm, and of the flexion of the wrist. The rotation osteotomy of the humerus above the insertion of the deltoid muscle is the method of choice. The pronation contracture of the forearm is corrected by osteotomy of both bones in the middle third. Flexion of the wrist is overcome by arthrodesis

of the radiocarpal joint with shortening of the tendons of the radial extensors. In one case of severe deformity of nineteen years' duration, the Sever operation was performed.—*Ernst Freund, M.D., Venice, Florida.*

SULLE ROTTURE DEL TENDINE DEL QUADRICIPITE FEMORALE (Rupture of the Quadriceps Tendon). Carlo Schapira. *Archivio di Ortopedia,* LII, 329, 1936.

Four cases of rupture of the quadriceps tendon are reported. The characteristic clinical picture is described. The roentgenogram is of importance to rule out fracture of the patella. Soft pictures may even show the interruption of the tendon. The treatment of choice is surgery. Relatively simple in recent cases, the therapeutic problem becomes considerably more difficult in inveterate cases. The wide diastasis makes a plastic operation necessary. Different muscles have been used (biceps, sartorius, gracilis, etc.) or the free transplant of fascia lata. From an etiological viewpoint, in addition to the trauma, predisposing changes in the surrounding tendon tissue have to be considered as they occur after forty to fifty years of age, as diminution of mechanical resistance and elasticity.—*Ernst Freund, M.D., Venice, Florida.*

CONGENITAL DISC-SHAPED LATERAL MENISCUS WITH SNAPPING KNEE. D. Stewart Middleton. *British Journal of Surgery,* XXIV, 246, Oct. 1936.

Four cases of persistence of embryonic disc-shaped lateral meniscus of the knee joint are reported. In each instance the patient had complained of snapping in the knee joint. The disc-shaped meniscus is more liable to be traumatized than the normal one. In the absence of trauma, the snapping sensation is painless.

The author speculates on the etiology of the snapping noise. He believes that in one type a ridge forms on the upper aspect of the meniscus with a concave facet in front of and behind it. When extension occurs the femur mounts the ridge and suddenly rides over it. In flexion the reverse takes place. In other types the snapping is due to the abnormal mobility of the disc.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

SOME EXAMPLES OF DISEASE OF THE VERTEBRAL COLUMN FOUND IN SKELETONS OF ANCIENT EGYPT. A CONTRIBUTION TO PALAEOPATHOLOGY. L. R. Shore. *British Journal of Surgery,* XXIV, 256, Oct. 1936.

This article is a museum of specimens and descriptions of unusual findings in vertebrae from the Predynastic Epoch. Many specimens of ankylosis of various types are described. It is evident that, even in such early periods, tuberculosis, tumors, infections, and trauma were the chief causes of spinal diseases.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

MULTIPLE ARTHRITIS IN PRESUMABLY TUBERCULOUS SUBJECTS: DIFFICULTIES IN DIAGNOSIS AND TREATMENT. Douglas H. Collins and Charles Cameron. *British Journal of Surgery,* XXIV, 272, Oct. 1936.

This is a very carefully written paper on the subject and part of the author's summary follows:

"The cases of twelve patients suffering from various forms of arthritis have been described. In eleven patients the arthritis was multiple. In eleven patients tuberculosis was suspected, and in eight visceral tuberculosis was proved. The arthritis in nine instances was finally not considered to be tuberculous. Six patients were wrongly diagnosed, in the first place, as tuberculous arthritis, and the detrimental effect of treatment adopted on this diagnosis has been recorded. Three early cases of spondylitis ankylopoietica with unusual symptomatology have been included.

The cases have been utilized to illustrate the difficulties in the early diagnosis of

tuberculous arthritis and to warn against the too ready acceptance of a tuberculous etiology in multiple arthritis occurring in presumably tuberculous subjects.

The facts which add confusion to the diagnosis of such cases, and which have been discussed and exemplified, are the following:

1. The insidious monarticular onset of some cases of multiple non-specific arthritis.
2. The coexistence in the patient of some visceral tuberculous lesion, which may or may not influence the course of a non-tuberculous polyarthritis.
3. The possible occurrence of a single tuberculous joint superimposed upon a non-tuberculous multiple arthritis.
4. The occasional incidence of a true tuberculous arthritis in two or more joints.
5. The comparative infrequency of non-specific arthritis of the hip in patients under middle age, and the tendency to suppose such a condition to be tuberculous.
6. Modification of the course of a non-specific arthritis due to early immobilization.
7. The possibility that there exists an atypical tuberculous form of polyarthritis—tuberculous rheumatism."—*Ernest M. Daland, M.D., Boston, Massachusetts.*

HALLUX VALGUS: A COMPARISON OF THE RESULTS OF TWO OPERATIONS. Eric I. Lloyd. *British Journal of Surgery*, XXIV, 341, Oct. 1936.

Forty operations were done on twenty patients. On one side the head of the first metatarsal was excised. On the other side the metatarsal exostosis and the base of the first phalanx were removed. The cases were reviewed one to three years after the operation and the patients were asked for their criticisms. Eleven patients could see no difference between the two sides; four preferred the side on which the metatarsal head had been removed, while the other five preferred the opposite side.

The author concludes that there is no difference in the results of the two operations. —*Ernest M. Daland, M.D., Boston, Massachusetts.*

SPONDYLOLISTHESIS: WITH A DESCRIPTION OF A NEW METHOD OF OPERATIVE TREATMENT AND NOTES OF TEN CASES. Walter Mercer. *Edinburgh Medical Journal*, XLIII, 545, Sept. 1936.

Mercer believes that in all cases of spondylolisthesis there is a bilateral primary center of ossification in the posterior half of the fifth lumbar vertebra. These usually unite in the region of the isthmus about the eleventh year. Due to trauma or to severe strain, there is a slipping of the epiphysis either with widening of the anteroposterior diameter without separation, or with actual separation at the isthmus,—a prespondylolisthetic state. Mechanical factors, including the shearing action of the upper posterior sacrum on the isthmus, then come into play, tending toward gradual stretching of the soft structures and production of spondylolisthesis. The typical clinical syndrome is described. Points to be noted in the anteroposterior roentgenogram are: (1) a characteristic arc or bow which is the outline of the front of the upper part of the body and transverse process; (2) a bitrochanteric length less than the bicristal length; and (3) an upward tilting of the lamina and spinous process of the fifth lumbar vertebra, which casts an inverted Y-shaped shadow. In the lateral roentgenogram, forward displacement, increase in the anteroposterior diameter of the vertebrae, Ullman's sign of forward displacement, and a gap in continuity of the vertebra should be looked for. Displacement forward is graded by the method of Meyerding.

The author reviews the operative methods and presents a new technique in which the anterior approach is used. The intervertebral disc between the fifth lumbar vertebra and the sacrum is resected together with a small part of the lower fifth lumbar vertebra. A wedge of bone from the iliac crest is inserted in the gap and is transfixed by screws slanting obliquely downward through the fifth lumbar vertebra. Of the ten patients whose cases are reported, two were operated upon by the author's method. One died postoperatively, due to superior mesenteric thrombosis; the second became pain-free and had full function with the exception of a stiff lower lumbar region.—*D. B. Slocum, M.D., Iowa City, Iowa.*

STUDIO SPERIMENTALE DEGLI EFFETTI DELLA IMMOBILIZZAZIONE SU ARTICOLAZIONI NORMALI (Experimental Study of the Effects of Immobilization on Normal Joints). O. Scaglietti and C. Casuccio. *La Chirurgia degli Organi di Movimento*, XXI, 469, 1936.

After a detailed discussion of the exhaustive literature concerning this question, the authors report the results of their experiments. They conclude that after immobilization of the knee joint three stages may be differentiated as follows:

1. Changes in the synovia, consisting in proliferation of the superficial layer, successive desquamation of the endothelium, retraction of the villi, atrophy of the synovia, diminution of the secretion of the synovial fluid, and, finally, sclerosis of the subserous layer.
2. Changes in the cartilage, consisting in loss of the basophile staining, irregularity in the cell growth, diminution in the height of the cells, and, finally, lesions and fissures.
3. Atrophy, loss of calcium of bone.

From the results obtained by their experiments, the authors confirm the statement that the three constituents of the joint—synovia, cartilage, and bone—are affected by immobilization.—*Joseph Wolf, M.D., Iowa City, Iowa.*

LA FALTA DE UNION DE LOS ARCOS VERTEBRALES COMO CAUSA DE LAS RAQUIALGIAS BAJAS (The Separate Neural Arch as a Cause of Low-Back Pain). Arthur Steindler. *Cirurgía Ortopédica y Traumatología*, IV, 81, 1936.

The separate neural arch may be considered as a clinical entity only in so far as it presents a syndrome similar to that seen in true gliding of the vertebra. From a pathogenic standpoint it must be considered as a precursory stage from which a spondylolisthesis may develop, whether intra-uterine, in early infancy, or in later life.

Considering the greater difficulty of detection by the roentgenogram as compared with spondylolisthesis and the occasional unexpected finding of a loose arch at operation, it stands to reason that the condition is considerably more frequent than is generally believed.

Because of the lesser deformity and the comparative youth of the patients, conservative treatment gives a higher percentage of good results than it does in spondylolisthesis.

Refractory cases which resist conservative treatment should be fused by operation under the same principles and with the same technique which applies to operation for spondylolisthesis.—*Alberto Inclán, M.D., Havana, Cuba.*

ARTROPLASTIA DE LA CADERA. CASO CLÍNICO DE EVOLUCIÓN ATÍPICA. (Arthroplasty of the Hip. A Clinical Case with an Atypical Evolution.) Alberto Inclán. *Cirugia Ortopédica y Traumatología*, IV, 109, 1936.

This case is interesting in that the surgical intervention failed and, in spite of it, a notable improvement was obtained, thanks to the extraordinary will power and perseverance of the patient.

The author points out that "static and functional reconstruction surgery of the joints requires, more than any other, the most decided and absolute cooperation of the patient, if it is to achieve its purpose".

"The first contra-indication to arthroplasty is pusillanimity and lack of trust of him who requires it."

The case presented illustrates this. The arthroplasty performed was quite lost by infection of a hematoma, with necrosis, not only of the interposed fascia flaps, but also of the cervical portion of the femur, which had to be removed later on as a sequestrum.

Two years after this second intervention, the patient returned for treatment. He walked with crutches and experienced pain as the femur ascended when he tried to bear weight on the affected leg. An operative reduction of the subluxation of the hip was performed and the hip was immobilized in a plaster spica in about 40 degrees of abduction. When the spica was removed, physiotherapy was instituted. However, the contact of the trochanter with the iliac bone caused pain which made walking impossible.

After an interval of some months the fourth and last intervention was done, consisting in a bifurcation of the trochanter after the method of Albee, which effected extraordinary improvement in the stability and in the function of the reconstructed hip. The patient now exhibits a motility of about 60 degrees for active as well as passive movements.—*Alberto Inclán, M.D., Havana, Cuba.*

KYPHOSIS JUVENILIS (SCHEUERMANNS KRANKHEIT). H. Scheuermann. *Fortschritte auf dem Gebiete der Röntgenstrahlen*, LIII, 1, 1936.

Scheuermann described this disease, also called kyphosis dorsalis adolescentium, fifteen years ago and in this article he gives a report on his experiences to date. Two or three vertebrae are commonly affected; the changes are frequently very marked in the construction and evolution of the limbus vertebralis. This may be entirely absent, it may lie near the anterior angle of the corpus, or it may not reach the anterior border. The shape of the limbus is also often modified. In rare cases the changes in the limbus begin a few years before its development, and a wedge-shaped vertebra results. Its origin may be explained as being due to the pressing of the spongiosa into the cartilaginous portion of the vertebral body. The irregularity of the vertebral contour may be considered as the result of the irregularity of the limbus in conjunction with oedematous nuclear prolapse, as has been described by Schmorl. Prognosis cannot be established in the early stage of the disease; kyphotic fixation may result within six months.—*Joseph Wolf, M.D., Iowa City, Iowa.*

LE TRAITEMENT FONCTIONNEL DES FRACTURES PAR COMPRESSION DE LA COLONNE VERTÉBRALE (The Functional Treatment of Compression Fractures of the Vertebral Column). V. Gorinevskaja and E. Drewing. *Lyon Chirurgical*, XXXIII, 44, 1936.

A study of reported cases reveals that not more than 30 to 40 per cent. of the patients have nerve symptoms depending on compression or oedema of the cord, which spontaneously disappear in a few months. Of the patients with severe destructive fractures, 81 per cent. entirely regained locomotion.

After discussing the usual present-day treatment of redressement and prolonged fixation in plaster-of-Paris and convalescent splints, the authors claim that this treatment retards recovery by hindering callus formation which is favored by the hyperaemia caused by use. A definite reconstruction of the architecture takes place over several months and even early in the treatment there is less danger of disalignment than there is after prolonged splinting.

Magnus and others consider that consolidation in these fractures is much more common than is generally believed, and they feel that bed treatment for six to eight weeks is sufficient and that return to work in from two to four months should be expected.

In addition to eliminating the corset, these authors advocate gentle exercises begun immediately after the accident and carried out daily under supervision while in bed. Under this regimen the roentgenogram does not show rarefaction. The authors extended this method to selected cases of compression fractures complicated by nerve symptoms, allowing the patients to begin to walk in about two to two and one-half months. They were not permitted to sit up until they had been walking from two to three weeks. As soon as they can rise and walk, they are given exercises for the standing position. They leave the hospital without corsets and walk for fifteen to twenty minutes, gradually increasing this period as they can up to from three to four hours.—*Joseph Wolf, M.D., Iowa City, Iowa.*

AN OPERATION FOR THENAR PARALYSIS. N. D. Royle. *The Medical Journal of Australia*, II, 155, 1936.

The serious disability in thenar paralysis is due to loss of function of the opponens pollicis muscle. The short flexor and short abductor are relatively unimportant. In the operation described by the author, one of the flexor tendons of the fingers is transplanted to the thumb. The author uses the bifurcated flexor sublimis tendon of the

ring finger, since that is the least missed. Three incisions are necessary,—one at the wrist, one over the base of the ring finger, and one over the thumb. Part of the tendon is sutured to the attachment of the short flexor with the phalanx in flexion, and the other part is stretched to the attachment of the opponens pollicis with the thumb in opposition. This is done by the living suture method,— that is, the tendon is the suture. After the thumb has been kept for ten days in the position described, reeducation is started. This is simple, for, whenever the patient attempts to flex the ring finger, the thumb is drawn naturally into opposition to that finger.—*Dr. Halbstein, Iowa City, Iowa.*

PEUT-ON TENTER UN TRAITEMENT CHIRURGICAL DE LA MYASTHÉNIE? (Should Surgical Treatment of Myasthenia Be Attempted?) J. A. Lievre. *La Presse Médicale*, XLIV, 991, 1936.

While the ultimate cause of myasthenia is unknown, it is interesting to note that in sixty-seven cases of myasthenia in which complete autopsy was performed, twenty-four had a mediastinal tumor in or near the thymic region; thirty-two showed a persistence of hypertrophy of the thymus; and in only eleven was there complete absence of thymic abnormalities. On the other hand, the thymic tumors which are not associated with myasthenia seem to be of the malignant lymphosarcomatous type. As a consequence of these and other cogitations, the authors come to the conclusion that there probably exists some connection between the benign thymomata and myasthenia. They consequently advise careful roentgenographic examination of the thorax in all cases of myasthenia. Where a tumor is disclosed, surgical removal is advised. Where the roentgenogram discloses no mass, a small tumor may still be present. In such an event, the authors recommend conservative therapy by means of medicines and x-ray. If the condition continues to progress, the ultimate, fatal outlook justifies surgical exploration of the anterior mediastinum for thymectomy.—*Henry Milch, M.D., New York, N. Y.*

LA PARALYSIE DU MUSCLE SOUS-ÉPINEUX (Paralysis of the Infraspinatus Muscle). André-Thomas. *La Presse Médicale*, XLIV, 1283, 1936.

The author reports the case of a young man, twenty-five years of age, in whom a peculiar loss of power of external rotation of the left shoulder appeared, following a strain when chopping down a tree. The patient noted weakness only in passing a heavily loaded plate to the left. It is the author's opinion that the function of the supraspinatus muscle is that of abduction and slight internal rotation, while the function of the infraspinatus is mainly that of external rotation. Since both muscles are innervated through the suprascapular nerve, the opinion is expressed that only the portion of the nerve supply to the infraspinatus was interfered with, since the function of the supraspinatus was maintained. In other words, the interruption to the nerve must have occurred at a point beyond the innervation of the supraspinatus. That this is below this point is proved by the fact that there appeared to be tenderness on direct pressure over the course of the nerve as it coursed around the base of the scapular spine.—*Henry Milch, M.D., New York, N. Y.*

DIFFERENTIAL DIAGNOSIS OF PERIARTICULAR FIBROSITIS AND ARTHRITIS. C. H. Slocumb. *Proceedings of the Staff Meetings of The Mayo Clinic*, XI, 363, 1936.

Fibrositis is the most common form of acute or chronic "rheumatism". Almost everyone suffers once if not oftener with it, at least in its mild, subacute form. Although widely recognized abroad and prevalent everywhere, it has received scant attention in this country.

Although the exact cause is not known, it is believed to be attributable to some unidentified infection or toxin. Trauma or exposure to thermal changes sometimes precipitates or causes attacks. Gonorrhoea, gout, rheumatic fever, and atrophic arthritis often affect extra-articular and periarticular tissues even more readily than intra-articular structures. Only the primary type—*i.e.*, without known etiology—is discussed here.

Anatomically primary fibrositis may be classified as: (1) intramuscular fibrositis (myositis) or "muscular rheumatism"; (2) periarticular (capsular) fibrositis; (3) bursal fibrositis or "bursitis"; (4) tendinous fibrositis which, in the palm, may lead to Dupuy-

tren's contracture; and (5) perineural fibrositis, of which "sciatica" or "brachial neuralgia" are common types.

The pathology is the same in all types and depends upon the severity and duration of the process. There is an inflammatory serofibrinous exudate with proliferating fibroblasts and newly formed blood vessels which may go on to indurated, local, tender, thickened tissue or frank, gross subcutaneous nodules. *There is no* leukocytic reaction.

Periarticular (capsular) fibrositis is much too commonly diagnosed as arthritis. In early cases the pain may be present only during excessive motion or during the first movements on awakening, and the patient may have to hunt for the soreness. If the disease progresses, pain becomes more constant and tenderness less elusive. Joints feel stiffer, but painful motion may still be readily accomplished. There is generally no swelling or hydrops, but capsular thickening may appear. There is little if any redness or muscle atrophy and the roentgenograms represent a normal condition.

In infectious arthritis there is fibrositis plus synovitis, chondritis, and osteitis. Similar in both diseases are: age incidence, age at onset, sex incidence, bodily types affected, and prodromal symptoms (fatigue, chilliness, nervous exhaustion). Atrophic arthritis tends to be a polyarticular invasion, and articular tenderness is expected. Fibrositis is usually found in one or two large joints or in several small joints, and there is generally little or no tenderness. Joints may feel subjectively better after moderate exercises. The sedimentation rate which is increased in atrophic arthritis is usually unaffected in fibrositis.—*Dr. Halbstein, Iowa City, Iowa.*

Les fractures des apophyses transverses lombaires (Fractures of the Lumbar Transverse Processes). P. Delcoulx et G. Patoir. *Revue d'Orthopédie*, XXIII 97, 1936.

In this study, 94 per cent. of the cases were in males. Two different types are distinguished,—direct and indirect fractures. The authors remark on the relative fragility of the apophyses; they appear very resistant in the dry bone, but in the fresh cadaver they are easily broken by moderate pressure.

The more important feature of the injury, however, is not the bone lesion, but that of the soft parts. The bone lesion itself cannot account for the pain that characterizes the clinical picture. To explain this, one must take into consideration muscular tears and aponeurotic lesions; also injuries to the nervous and vascular systems, more or less extensive hematomata, etc. The lumbar nerves in particular are in close contact with the neck of the transverse processes. The anatomical course of these fracture injuries is also very different: four eventualities are possible:

1. In the first group, there is normal consolidation and the callus forms in the same manner as in other parts of the skeleton;

2. In the second type, exuberant callus is formed, which explains the compression symptoms, nervous radiation, etc.;

3. In the third group, there is progressive absorption of the detached fragment;

4. In the fourth and most frequent type, the detached fragment rests in place and undergoes little or no modification of structure.

The symptomatology also admits the classification into four categories: (1) the habitual form; (2) the benign group; (3) the masked form; (4) severe fracture with abdominal contracture. The authors cite appropriate cases for each of these groups.

The pathogenesis of this contracture is hard to explain; it resembles that found in retroperitoneal or perirenal hemorrhages.

The later course of all of these fractures is no less varied than that of the clinical forms. Some of them may heal rapidly without any trace, but many leave behind a certain rigidity of the spine. There are also neuralgias localized in the lumbar spine and radiation in the abdominal border of crurogenital character, which are very resistant to treatment and may last months and even years. In the cases of the authors, the permanent partial disability was on the average 52 per cent.

Therapeutic indications are very variable. Treatment includes only two possibilities,—either complete conservatism or surgical removal of the fragment. The conservative method is most frequently employed and was used in all of the author's cases. The patient is put to bed for two weeks and massage and electricity or diathermy are applied. A plaster jacket is useless. Injection of cocaine is often of service. The operative technique is also discussed.—*Arthur Steindler, M.D., Iowa City, Iowa.*

PATELLA PARTITA AND ITS CLINICAL IMPORTANCE. A. Pytel. *Slovanský Sborník Ortopedický*, X, 9, 1935.

Seven cases of patellar anomaly are presented,—four with one body at the upper outer pole; one with separation of the inferior pole; one with separation of the medial pole, the other side having the usual type at the upper outer border; and one of duplex patella. Four cases were bilateral.

All of these anomalies are congenital in origin and are found in from 1.5 to 2 per cent. of roentgenograms of knees. With duplex patella are associated varied skeletal anomalies.

Superimposed trauma usually is the cause of the pain which these patients experience. The knees are inferior in type and are easily injured. As a rule, all improve under physiotherapy.—*W. R. Hamsa, M.D., Iowa City, Iowa.*

X-RAY THERAPY IN ORTHOPAEDICS. Jaromir Stepan. *Slovanský Sborník Ortopedický*, X, 297, 1935.

X-ray radiation over plastic reconstructed joints for ankylosis is used by the author to facilitate the production of fibrous tissue over the bone ends. This is begun at the time motion is first attempted and is administered in one to three series, each series consisting of about four radiations at weekly intervals. Dosage is 150 roentgen units, from a different direction at each treatment, filtered through eighty-seven hundredths of a millimeter of copper and a filter of three-tenths of a millimeter of copper plus one millimeter of aluminum.

Tuberculosis of bones and joints is similarly treated. Peripheral joints, however, are first temporarily deprived of their blood supply by a rubber bandage. In the author's opinion, all stages of the disease are benefited. He believes that roentgen therapy has a definite place in orthopaedic surgery.—*W. R. Hamsa, M.D., Iowa City, Iowa.*

OSSEOUS CYSTS OF THE PEDAL NAVICULAR. Aleksander Manzoni. *Slovanský Sborník Ortopedický*, XI, 1936.

The case reported is that of a twelve-year-old male who complained of pain in the left foot, localized to the midtarsal joints. There was no history of trauma. Physical examination showed pronation of the feet with planus and a prominent scaphoid medially, with tenderness to pressure. Roentgenograms showed a cystic area in the tibial half of the left scaphoid, surrounded by a sharp sclerotic border. Operative findings were a cyst containing serous fluid, and thickened periosteum. The pathological diagnosis was productive circumscribed periostitis with cyst formation. The author believes all similar cysts are on a traumatic basis.—*W. R. Hamsa, M.D., Iowa City, Iowa.*

ACUTE OSTEOMYELITIS. Etiology, Symptoms, Diagnosis and Treatment of Eighty Cases. Joseph I. Mitchell. *Southern Medical Journal*, XXIX, 588, 1936.

This article is based on eighty cases of acute infectious osteomyelitis of hematogenous origin. The incidence, location, predisposing causes, causative organisms, pathology, symptoms, diagnosis, treatment, and results are recorded. The author believes that early diagnosis and early treatment improve the prognosis. The operation is conservative, consisting merely of drainage. However, incision of the periosteum gave as high a death rate as drilling into the bone. Mortality was higher in cases caused by streptococcus hemolyticus (33.3 per cent.) than in those due to staphylococcus aureus (10.3 per cent.). Staphylococcus aureus was present in 65 per cent. of the cases. The persist-

ence of positive blood cultures is a bad prognostic sign. Blood transfusions are a valuable aid in treatment.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

TUBERCULOSIS OF THE SPINE WITH PARAPLEGIA. J. H. Kite. *Southern Medical Journal,* XXIX, 883, Sept. 1936.

The history of this condition is touched upon. Twenty cases with paralysis and ninety-six cases without paralysis from the Scottish Rite Hospital for Crippled Children, Decatur, Georgia, are studied. Carefully prepared tables show the age incidence, location of lesions, number of vertebrae involved, duration of disease before onset of paralysis, treatment, time required for recovery, and the results. A significant finding is that the region most frequently involved in the paralyzed group was from the fifth to the ninth thoracic vertebra, while the region most frequently involved in the non-paralyzed group was from the ninth thoracic to the second lumbar vertebra. "Paralysis is seldom due to bony pressure at the point of angulation, but is due to pressure on the cord from the products of tuberculous inflammation. . . . If the paraplegia occurs shortly after the onset of the tuberculous lesion in the spine, the prognosis is good. If it comes on late, five years or more after onset of the disease, the prognosis is poor." Younger children recover better than the older ones.

Patients receiving adequate treatment early after the onset of paralysis recover better than those who are treated later. Laminectomy in this series did not hasten recovery. The author states that when paralysis has disappeared a spine fusion should be done to cure the tuberculous bone lesions.

This article is a valuable contribution to our knowledge of paraplegia as a result of tuberculosis of the spine.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

DIE ZWECKMÄSSIGE EINLAGE (Suitable Foot Plates). M. zur Verth. *Zentralblatt für Chirurgie,* LXIII, 1117, 1936.

The author classifies foot pain into three different types. At first, especially after exertion, the patient feels a slowly increasing tiredness. The site of this pain is most commonly the calf and the tibialis muscles. After a short time, tension pain occurs in the foot joints, especially at the dorsum near the ankle joint. Sometimes this leads to a voluntary abnormal position of the foot in walking, especially on the outer border of the foot. Often morphological changes occur,—for instance, sinking of the second and third metatarsal heads and tension of the toes in cavus. The third stage consists of pressure pain from weight-bearing on the weight-bearing points. Therefore, a good foot plate must function in such a manner as to cure these three types of pain.

The author claims that in the construction of a good foot plate seven different points must be observed:

1. The plate must provide autostatic reduction. The foot plate has to reduce the foot so that the plumb-line from the hip falls in the supporting surface of the foot, as close to the length axis as possible.
2. The plate must preserve its shape independent of the shoe. Nevertheless elasticity is required.
3. The foot plate must be changeable and adjustable. The plaster model furnishes only a rigid shape of the foot and does not indicate the change of form in gait. Therefore, the foot plate constructed from a plaster model must be adjusted on the living foot.
4. The foot plate must not compress the foot more than is necessary. The function of muscles, tendons, vessels, and nerves must not be impeded.
5. The plate should not require too much room, so that the patient needs to buy shoes which are too large. In most cases an external border is not necessary to prevent the sliding outward.
6. The plate must not be too heavy.
7. The plate should not be too expensive, and it must be durable.—*Joseph Wolf, M.D., Iowa City, Iowa.*

the long story of Medicine, certain names stand forth in resplendence. To some of them we are accustomed to look as the pioneers of what we, today, call Orthopaedic Surgery. In like manner, we might as well hark back to the mythical Vulcan and to Tubal-cain, the fashioners of metal; to the inventor of the lever and the screw we might turn as great contributors. But the master of modern constructive methods was he who first learned to ascertain the stresses which must be borne by materials and to compute the resisting capacity of the various ones. Only thus, out of the great conglomerate of discoveries and inventions, could come the later contrivances of men and those complicated devices which have become so integral a part of our modern civilization.

If we have decided to put away from us the temptation to sift through historical chronicles in order to segregate each single human accomplishment which may, by any stretch of the imagination, be said to belong to the resources of Orthopaedic Surgery, we shall nevertheless have to find a starting point. The derivation of the word "Orthopaedia" has been commented upon so often that I shall not willingly add more. However, like Banquo's ghost, it will not be downed. There is, in fact, a ghost which requires to be laid and it is that of Andry, himself, in whose book the name first appeared. I have had before me Andry's book, published in 1741, as well as two small volumes of even greater interest. They constitute an English translation with additional comment and are of the date 1743. The essential fact in both of these is that the treatise deals with the cosmetic aspects of the child,—it has to do with the appearance of the body almost exclusively, and it is concerned with the hair, face, eyebrows, nose, eyelids and lashes, pockmarks, pimples, gums, and even artificial teeth. It is a book for the layman and makes not the slightest pretense of being a scientific contribution, even in the spirit of its own time. In short, Andry has bequeathed to us naught but a name,—a name, however, whose present usage no longer resembles that of the original even remotely and some of whose other implications make us inclined to writhe. Would that I might give to you a better and say to this name: "*Requiescat!*" But I shall not try to do so.

SPECIALISM

The conditions leading up to the development of specialism, as we know it today in Surgery and in Medicine, may be observed in their gradual appearance as far back as the records of our profession can lead us. I do not mean this in the highly exaggerated sense of ancient Egypt, where an individual learned nothing beyond the concerns of the one organ upon which his interest was centered. There is no purpose in being occupied with detail, at the moment, but it may serve us usefully to glance at the causes whose slow accumulation and effects have produced what is, perhaps, the one thing which distinguishes Medicine of today from that of the recent past. It seems fairly certain that the first step toward specialism did not lie in the increase of knowledge, but, rather, in

the consciousness of some persons that they possessed certain talent or skill to do particular things, by means of their personality or with their hands, which were not at the command of others about them. The demonstration of such specialized ability was productive of enhanced reputation among the people, but, at the same time, it did great violence to the canons of a profession which was still in its swaddling clothes. Medicine depended, for the most part and in olden times, upon empiricisms and rationalizations which had no real physical basis and which were destined to disappear with increase of knowledge and that arrangement of observed phenomena which we call "science". Hence we find in the Hippocratic oath the prohibition against cutting for stone; for many centuries after the physician of Cos, we find relegated to the barbers all of the cutting procedures as well as the other things done for patients with the hands. These things were assigned to the barbers as being beneath the dignity of the truly learned. The differentiation of the "*Chirurgus*" from the "*Medicus*" out of the number of persons offering help to those in impaired health seems to have occurred long before the term "*Doctor*" was used, since this designation was an ascription of unusual knowledge in its connotation of the ability to teach and in its significance of a career of scholarship and of philosophical study. I have little doubt that primarily there was associated with the idea and claim of special skill the conception of a restriction of knowledge and of activity. The comparison of such a narrow sphere with that of one concerning himself with the whole of human ratiocination would not have been considered flattering. We have only to remember that the scholar occupied himself with everything which man found in relationship to the world about him and, scarcely less so, in respect to a world to come. Slow, indeed, was the process of separating the chaff from the wheat and even painfully gradual, at times, the incorporation into our assets of many things which had come from outside the precincts of learning as they were formerly circumscribed. The attempt to establish recognition for any of the special branches of practical medicine and surgery has nearly always met with lay approval and collegial antagonism. I have encountered an amusing example dating prior to 1825. John Abernethy was the immediate successor to John Hunter, the great Professor of Surgery, in London. Though gruff in manner and of testy disposition, he was highly esteemed as a surgeon and a teacher and greatly admired for his fine character. Upon being requested to accept appointment as Honorary President to the London Eye and Ear Infirmary, he declined and used the following words: "I can see no good that can arise from this to the public; it may be of use to the surgeons, but I candidly tell you I consider it quackery; I will never lend my name to sanction it; every surgeon should be acquainted with the diseases of the organs of sight and hearing; and to detach them from regular surgery would be not less injurious to the science than oppressive to the public." It would be pointless to attempt an analysis of the motives underlying such an attitude, or to ascribe to them

an unworthy character. Specialism, both within Medicine and outside of it, has faults and shortcomings, but it has justified itself by what it has accomplished.

I feel as if I had the right to say at this point that Orthopaedic Surgery was one of the first specialties to be practised as such, to the exclusion of other branches of Medicine and Surgery, except as they were necessarily involved. In its earlier American interpretation, fractures and other acute conditions were not dealt with. It is very significant to me that this is still true of most of the European texts on Orthopaedic Surgery. This is particularly the case with those of German authorship,—a matter of especial importance, since, after its development in America, Orthopaedic Surgery found its most luxuriant flowering in Austria and in Germany. It would appear significant to consider the essential basis upon which this early development rested. Even though nowhere stated in such terms in the literature of the period, it seems fair to say that until approximately 1889 *Orthopaedic Surgery consisted of the application of mechanical principles and methods to the correction and cure of the deformities and diseases of the motor apparatus of the body;* it was concerned chiefly, therefore, with the trunk and the extremities. Operative procedures, involving the use of the knife, were largely restricted to very simple ones, such as tenotomy, myotomy, fasciotomy, and the incision of abscesses. I have already said that fractures in their acute phases and acute pyogenic osteomyelitis were not considered as belonging in this field. Corollary to this is the fact that the contributions of original character which came from the group of orthopaedic surgeons during this period were concerned chiefly with mechanical appliances and with manipulative procedures, done perhaps under general anaesthesia, but involving cutting methods of the simplest nature only. It was not long before orthopaedic surgeons were looked upon by general surgeons as an inferior class and were spoken of with contempt, often undisguised. Witness the words spoken by Dr. E. H. Bradford in his address as the third President of the American Orthopaedic Association, in 1889: "But though great progress was made in Orthopaedic Surgery, it is not to be overlooked that it fell from the high estate it held in general surgical interest fifty years ago, until it became an almost despised and rejected branch. The orthopaedic surgeon was regarded as a man of mere straps and buckles, or the custodian of that surgical chamber of horrors, the orthopaedic institute. The reason of this decline of interest is not far to seek, if we recall the fact that fifty years ago the attention of the surgical world was turned to the remarkable feats of the great surgeons who taught us precision, skill, and boldness in the triumphs of the amphitheater, and that the ambition of all men of energy prompted them to emulate those monarchs of the operating table."

It seems especially worthy of note that even after Orthopaedic Surgery had begun to take a place as a specialty, the innovations which were introduced in great profusion for a number of years by its early apostles

belonged in the field of mechanical contrivances. Lengthy discussions ensued as to the comparative advantages of more or less radical operative methods, as contrasted with mechanical, conservative, or the so called "bloodless" modes of treatment for the same abnormal conditions. In the meantime, the steady advances in surgical pathology and bacteriology were receiving rather scant notice from a group whose attention was fixed upon the therapeutic use of mechanical appliances, the study of the disease processes themselves being permitted to remain in the background. Thus can be explained the controversy between the "American", the "English", and the "Austrian" schools concerning the relative advantage of treating chronic disease of the joints of the lower extremities by traction, by stilting, or by splinting, and by various combinations of them. Meanwhile, the solution lay in the study of the disease process itself,—in the distinction between conditions which were truly tuberculous and others which, however much they appeared to be so clinically, came to be known as non-tuberculous. Furthermore, scientific study of the processes of repair was necessary in order to determine how these diseases could be cured. While all of this therapeutic discussion was going on, significant advances in knowledge concerning the true nature of the diseases of the bones, the joints, and their controlling structures were being made; above all, the profession was learning what was really meant by the word "cure" in tuberculosis and how and when it could take place. Was a patient with spinal disease to be regarded as cured simply because, under the protection of a steel support, he had shown no symptoms for a number of years? The definite answer had to come from the laboratory. Even at the risk of courting a reply which may be somewhat unpalatable, let us inquire into the sources of the knowledge which was destined to constitute the basis of much of the progress which came into being. We encounter the names of Brodie, Paget, Ollier, Volkmann, MacEwen, Mikulicz, Lannelongue, König, and Lexer, not to mention many others. The contributions of these men appear to be especially emphasized inasmuch as they consisted of additions to our knowledge of the nature of morbid processes and their behavior under varying circumstances involving or not involving the modifying influence of therapeutic methods. But, be it observed, these are the names of general surgeons working in the academic atmosphere of investigation. The questions may well arise: Were these men better fitted to make these important and basic contributions in the realm of the motor apparatus because they also studied the viscera? Was any one of them better fitted to operate upon the knee joint because he was even more concerned with the surgery of the large bowel? Could it even be said that continued participation in the surgery of the motor apparatus was vital to the maintenance of their general surgical standards? Not at all so, it would appear. It would seem more likely that their contributions could be attributed to the fact that all of their activities were built upon a broad and truly scientific foundation and, ancillary to this, there was necessarily involved the spirit of in-

quiry and the habit of constant search into the nature of underlying principles.

THE COURSE OF EVOLUTION IN ORTHOPAEDIC SURGERY

Up to the time of the development of bacteriology and the consequent antiseptic or Listerian era in surgery, Orthopaedic Surgery was merely a part of the activities of every general surgeon. The contributions to it were partly his and partly, one might justly say, they came from more or less capable artisans who had no academic training whatever. Some of these men provided the surgeon with his operative and other instrumental equipment. Others, like Heine and Hessing in Germany, applied themselves to devising mechanical appliances for the treatment of deformities. In the case of the two just mentioned they did not hesitate to undertake the actual treatment of patients, not infrequently with success as judged by the standards of the time. Often patients were referred to them by accredited members of our profession, who left to them virtually the chief, if not the whole, task of directing and conducting the treatment. That in so doing these surgeons acknowledged their own ineptitude is quite beside the point. The fact is that it was done. Unhappily, we may witness something equally culpable in our own time when patients are sent by physicians to osteopaths and chiropractors, on the unsound reasoning that they have an especial training in physiotherapy,—a statement which would not be so bad were it not wholly untrue. But these were the days when men might with justice speak of "Orthopaedics" and of men like Heine and Hessing as "orthopaedists", for this is what they were; indeed, for years afterward there were many others like them, even though they were dignified with academic degrees.

The fact is that there was no body of information or technique which called for concentration of effort in the minds and hands of a distinct group, in so far as the field of the bones and the joints was concerned, except as the talents and predilections of certain men directed them toward it. When Venel organized the first orthopaedic institute at Orbe, Switzerland, in 1780, he became the first truly specialized and professional "orthopaedist"; this he was, *par excellence*, as far as we know. It is possibly also true that in so doing he laid the ground for that isolation from the rest of surgery which later took place, as well as for a contemptuous attitude on the part of general surgeons which may at times not have been without some justification, granting that there is ever an excuse for it. Shunting aside the blameworthy conduct of certain individuals, there should never be a place for such professional snobbery. When Stromeyer, during the first half of the nineteenth century, popularized the operation of tenotomy for club-foot much good was accomplished, but not a little harm was also wrought. By reason of the operation which Stromeyer performed on the English surgeon, W. J. Little, an enthusiastic advocate was made of Little, and this eventuated in the organization of the Royal Orthopaedic Hospital in London. This operation

was the main feature of Stromeyer's treatment, aided as it may have been by retentive apparatus. We know today how imperfect the end results of such a plan of treatment are bound to be in the majority of instances, whether of the congenital or of the acquired form. While the results which he achieved probably constituted an improvement over those previously obtained, years had to elapse before the essential shortcomings of the method were acknowledged,—before it was realized that very often, yes, most often, the premature performance of tenotomy is unfortunate in its definitive effect, and that *per se* it must usually be regarded merely as a step in the treatment, however useful it may be if done at the right time and properly combined with whatever else is needful. It must surprise those who know these things, in reading the literature of Stromeyer's time, to receive the impression that his patients were cured by the operation. We look in vain for statements of recurring deformity and disability, fully aware as we are that they must have taken place, time and again. It is refreshing to learn that Little eventually made acknowledgment of the shortcomings of tenotomy as a procedure to be relied upon exclusively and if used without discrimination. In Stromeyer, then, we have another example of one who made a useful contribution, but did not do overmuch toward shaping the fundamentals of what was destined to become a field of useful labor for a large group of specialized workers. Soon after the beginning of the Listerian era in surgery came the period of so called "primary resections" for tuberculosis of peripheral joints. Incidental to the recognition of the identity existing between "white swellings" of the knee and ankle and pulmonary tuberculosis, there ensued a veritable "*furor operandi*". Much time was needed to show the futility of these procedures as they were then practised and in view of the after-treatment then in vogue. The frequent incidence of operative infection brought with it the necessity for many subsequent amputations. Mutilation of the epiphyseal growth centers had the lamentable effect of later shortening of such degree that amputation was often found preferable, notwithstanding the unhappy alternative of the inferior prostheses available at that time. Even when such catastrophes were evaded, many of those in whom primary healing was obtained were visited with recurrence *in loco* or at a distance, due to failure of the surgeon to realize that he was dealing not with tuberculous joints but with tuberculous individuals. However obvious such episodes appear to us now and however plain their cause, a long and dreary road had to be travelled by patients and surgeons alike before the nature of the mirage became evident. Witness now that phenomenon in our professional record which we have still to observe on occasion, albeit not characteristic of us but incidental to the imperfection of human reasoning and the enthusiasm of the innovator,—the pendulum having swung too far to the left must move equally far to the right before it assumes a central position. How true this is, not only of individuals or of groups, but even of nations in their corporate affairs! The voice of protest is not heard in the

tumult—or being heard it is drowned in a flood of imprecation and the charge of reaction or of inertia. Thus are we so often prone to lose the lessons which the past may bring us, would we but look for them with the enlightened mind of the present. In this situation, the revulsive attitude of mind, representing the swing to the extreme right and following upon the disappointing outcome of the radical operative policy, became manifest in the United States. Implicit in the genius of this country there appears to be an urge toward the purely mechanical and the inventiveness coupled with it. It is not strange that this flair for mechanical improvisation now invaded the field of surgery also. Long before the essential nature of tuberculosis of bones and joints became clear through the results of pathological and bacteriological research, these lesions had been spoken of as inflammatory, irritative, and destructive. Two opposing schools of thought arose with regard to treatment. If the one group projected their theory that complete physical rest of the body was called for and fortified it by demonstrating the rapid improvement of patients thus treated, both in respect of their local and general condition, the opposition was able to show that the lack of fresh air and sunshine vitiated these results in the end. "Hectic fever", the development of abscesses, and an eventual increase of mortality were pointed to as contra-indicating the institutional method. It is quite amazing how much time had to elapse before it was realized that these views were not truly in opposition, but that they could be reconciled, as they are in fact today. In the meantime, discussion was active in the attempt to explain what was accomplished by rest in recumbency, to what degree complete immobility of the affected joint was needful and desirable, to what extent recovery with loss of motion was dependent upon enforced fixation, and in what measure recovery could take place in defiance thereof. "Natural cure" of certain joint affections, usually with complete loss of motion, was pointed to as indicating the course which our therapeutics should imitate. That entirely differing diseases were being dealt with, at least very often, was in no one's mind. American engineering proclivities soon envisaged a mechanical solution and posed three possibilities for the control of peripheral joints and the spine, as they might be employed singly or in combination. The principle involved was not of American origin in any case; the methods employed were. You may not forgive me for recounting them today; they have almost passed into the limbo of things forgotten. The elements of joint control comprised:

1. Fixation—the restraint of all articular motion to the maximum degree possible.
2. Distraction—the pulling and holding apart of joint surfaces in order to prevent attrition.
3. Stilting—the removal of superincumbent weight to eliminate the percussive effect of walking.

When I say that these things have been almost forgotten, I mean only as they were considered the central objective of treatment. As incidental

and temporary features of treatment, they are all still in use. However, it seems rather unimportant that in the discussions which took place, largely as the result of mechanical contributions from American sources, it was assumed that the axiom of the so called "American School" in the treatment of chronic disease of joints of the lower extremity lay in the dictum that to the extent that motion could take place without friction it was permissible,—that is to say, not harmful. Equally unessential does it now appear whether we take sides with those who endorse the plaster-of-Paris jacket of Sayre in providing fixation and correction of the spine, or with those who favor the steel brace of Taylor in furnishing anteroposterior leverage capable of adjustment as occasion requires. We may admire the simple appliance of Judson for infantile club-foot, or the more complicated machine of Bradford for the reduction of congenital misplacement of the hip. In similar category we may view the many ingenious forms of wrenches with which to apply force externally in correcting deformities. Many of them have been laid aside to the degree of being considered obsolete. Others are still in use. From all of them we have learned something. Common to all of them, however, is the fact that none of them is employed with the constancy and adherence to underlying mechanical action which was originally in the mind of the inventor,—certainly not with the faith in their utility which was his and was by him transmitted to his disciples. It seems fair to say that at this period the attention of the orthopaedic group was fixed much more upon the methods of cure than upon the study of the nature of the diseases which they sought to influence. Turning for the moment from this incomplete glimpse of the mechanical contributions made in this country at an inchoate period of the modern surgical era, let us have a glance at the literary product. It is best found, perhaps, in the transactions of the American Orthopaedic Association, which was organized in 1887. It is important that this be done since it must be realized that, even though many men in many countries and throughout many generations had been doing things which we now consider to belong preeminently within the domain of Orthopaedic Surgery, we have here the opportunity of observing the beginnings of its practice by a specialized group. So far as I know, for the first time in medical history, a number of men, a majority of whom confined their professional efforts to this field, banded themselves together for scientific purposes as orthopaedic surgeons. A quick excursion through the earlier volumes of these Transactions will enable us to note the general character of the papers. No Claude Bernard is to be found among the authors; yet I cannot forbear pausing at this juncture to pay a humble and sincere tribute of homage and admiration. This is not simply by reason of the impressive character of the authors' names. Mingled with the names of Shaffer, Davis, Taylor, Sayre, Bradford, Gibney, Whitman, Ridlon, Sherman, Steele, Gillette, Willard, and Lovett, we shall find many others no longer familiar. The presence of these other names is testimony that they had something to say. What is more

significant to me is that they were encouraged to say it. The protocols of the discussions will be found eloquent of their objective nature but, what is more important, redolent of a fine spirit toward the younger men on the part of those who had already arrived at the stage of leadership.

As we pass in review the list of titles of papers published in the early volumes of these Transactions, we find a predominance of those dealing with clinical descriptions of deformities and the diseases producing them, of mechanical methods used in their treatment, of mechanical appliances and the indications for their use. This was the period to which I have already alluded and in which the dominant idea was *the application of mechanical principles and methods to the correction and cure of the deformities and diseases of the motor apparatus of the body*. However, the scientific ferment was early at work. Already, in the second volume, we find "An Experimental Study of Distraction of the Hip Joint". This was by Dr. E. G. Brackett, now Honorary Member of the Association and, since 1922, the editor of *The Journal of Bone and Joint Surgery*. Nine years later, we find R. W. Lovett, in his address as President, calling for more investigative work and the study of pathology. In this same volume is included a paper by the talented E. H. Nichols on the pathology of "Tuberculosis of Bones and Joints". From thence forward, even though slowly at first, we observe an increasing interest in the study of the motor apparatus in its mechanical implications, their relation to physiological function, and those departures from it which bring people to the orthopaedic surgeon. Lovett, himself, made a lasting impression by means of his studies on the mechanics of scoliosis.

It must here be observed that the approach to scientific methods of research with respect to the motor apparatus had been made quite a long while before the beginnings of Orthopaedic Surgery in America, by European workers who had no such specialized interest. Such is the pioneer work of Weber on the mechanics of human locomotion, dated 1836. Investigative effort in the sphere of orthopaedic interest had been undertaken in Germany, in Italy, and in other European countries quite a few years before it was in evidence on this side of the Atlantic. During my own student days abroad, a very strong impression was made upon me by the work of Julius Wolff on the architecture of bone. While his studies have not had the practical application to which he had considered them predestined, their significance has been both misinterpreted and undervalued, in my opinion. To summarize the meaning of Wolff's work in the words of Murphy, that "the amount of growth in a bone depends upon the need for it", gives a superficial and false notion of what Wolff really tried to show,—what many informed persons today believe that he succeeded in demonstrating, others to the contrary notwithstanding. Had it been said that Wolff had merely shown that bone is a living material which responds to function, both normal and abnormal, in a manner analogous to that displayed by all of the other body tissues, the

simplification would have had a better justification. Such a statement, however, conveys a conception entirely different from that of Murphy. It is at least correct, even though inadequate.

The tenth decade of the nineteenth century brought with it a discovery which was to exert an influence of the most profound character upon the development of Orthopaedic Surgery. This was the roentgen ray. Its practical application in medicine really began about 1900. The result was a change in the diagnosis of bone and joint lesions which was very far-reaching in so far as it brought about a degree of accuracy hitherto unattainable. But it did much more than this in making possible the recognition of conditions with which we had been until then totally unacquainted. I need only to speak of such conditions as epiphysiolysis of the upper end of the femur, the various forms of osteochondritis, and the identification of lesions which before that time it had not been possible to differentiate from tuberculosis. Now of admittedly great value and of constant employment in every department of Medicine and Surgery, one feels justified in saying that the influence of the roentgen ray has been nowhere so great in bringing about diagnostic accuracy and in changing the therapeutic trend as in Orthopaedic Surgery. It has been the means of making possible a wholly new line of experimental research which has still very far to go. It has not only told us with much more exactness what is required to be done, but it has given us a measure, of unexampled value, of what has been accomplished. Most significantly, however, it has added greatly to the scientific stature of the orthopaedic surgeon. He has had to become an accomplished interpreter of the roentgen-ray picture. Viewing the various permutations of bone structure and of other tissue changes, as produced by disease and injury, he has become a better pathologist through having to reconcile these changes with their underlying processes. That with this new acquisition there has also come a great number of entirely new doubts, calling for resolution, is easily comprehended, and progressive orthopaedic surgeons are today applying themselves vigorously to this task. The point of it all is that this one factor has, within a few years, completely changed the outlook of the orthopaedic surgeon, as well as his practice. The accompanying disappointments must act in the end to elevate the standards of his work. The roentgen ray has made of the orthopaedic surgeon much more of an operative surgeon than he had been before, for it has shown him that many things which he had been trying to do in a so called "conservative" or non-operative manner could be accomplished more quickly, more comfortably, or, best of all, more effectively, in this way. Still more vital is it that he has thus learned to do things by open operations which would otherwise have been impossible.

This much more frequent recourse to operative methods is, therefore, the next trend of evolutionary nature to be taken into account. According to our preapprehensions, it may be looked upon as a step forward or, on the other hand and by the conservative "die-hard", as one in

the opposite direction. It is my contention, however, that he is not less "orthopaedic" who has become more "surgical"; he is not to be held as having surrendered his time-tried accomplishments who has changed his perspective by reason of increased knowledge and experience. What has been his in the form of mechanical contrivances and of physical therapy has not been lost to him because he is trying to put things in their proper places. He is rather to be lauded for making the effort. To be censured is he, only, who regards operation as "be all and end all" instead of looking upon it as a desirable step in the treatment of his patient. I need say nothing of him who operates with an eye to his own advantage. It has always been my contention that Orthopaedic Surgery is a distinct discipline in Surgery; but never anything but Surgery. To limit the use of the term "surgery" to operative methods with knife and other instruments involving blood loss is to commit a definite solecism.

In its oldest connotation, Orthopaedic Surgery was concerned mainly with the prevention and correction of deformity. This idea was always associated with the skeleton and its components, since it is these intrinsically which give form to the body. Thus, the bones have had the foremost place in the vision of the orthopaedic surgeon and not seldom to the neglect of the rôle which is played by the muscles and other soft tissues, a rôle which is frequently of dominating importance. The demonstration of this fact by the great Duchenne has had a directing influence whose importance cannot be too greatly emphasized. However great the preponderance of the skeleton in the minds of the earlier orthopaedic surgeons, they did not busy themselves with the acute lesions and injuries involving it, but only with their objectionable consequences. With fresh fractures they were not occupied. Soon following upon the advent of the roentgen-ray era, this situation began to change and for reasons not difficult to understand. The roentgen ray brought with it that same precision in the diagnosis and treatment of fractures that it contributed in the case of disease in bone or joint. It also made possible the study of fractures, not simply as wounds of bones,—as solutions of continuity which require to be healed, as it were. Every fracture now presented itself as a potential threat of a continuing disturbance of the human mechanism such as the orthopaedic surgeon had been studying hitherto, but always after the fact. If he had now before him the terms of the problem with a new accuracy, he had also an insight into the solution of it and it appealed to him that he was himself particularly endowed with those attributes which were specifically demanded. He felt that he possessed them by reason of his own peculiar training and experience. There followed now an active participation by orthopaedic surgeons in the treatment of fresh fractures. It may be said with confidence that the results have not been disappointing. The contributions which have been made by orthopaedic surgeons in this field have been notable and their proficiency is being generally acknowledged. In some of the leading medical schools, the teaching of fractures is now assigned to orthopaedic surgeons. This but cor-

responds to an assumption of their responsibilities in full measure. However, it must be realized that the treatment of fractures must be a prominent part of the equipment of every general practitioner, as well as of every general surgeon. In ordinary practice neither of these groups should have fractures of ordinary kinds separated from their work, but the orthopaedic surgeon should be marked with an accentuated proficiency in this field, especially in cases where the mechanical problems are complicated and in which unusual and appropriate skill and experience are called for in respect of mechanical design and application. *This, too, is surgery.*

From what has been said, it must be obvious that there has been a significant shift in the attitude of the orthopaedic surgeons since the time of their integration as a group. It involves a departure from the original emphasis upon the application of mechanical methods in treatment as the point of primary importance. In consonance with the present conception, we might better point to the mechanical and motor functions of the human organism as occupying the foreground. If the statement accords with fact, it implies a shift in position of no slight significance. Perhaps a more fitting statement would now be: Orthopaedic Surgery signifies the application of surgical methods to the injuries, diseases, and dysfunctions of the motor apparatus of the body, with especial regard to its preeminently mechanical faculties. The groundwork for such an attitude was laid quite long ago. It has been asserted repeatedly that every mechanical principle employed by man in his external relationships is to be found exemplified in his own body. However, only since the early part of the nineteenth century have there been serious attempts at the study of the human body as a motor mechanism. Such are the products of the Weber brothers, Fick, Roux, Wolff, Ghillini, Lovett, Goldthwait, Steindler, and others. The subject is difficult and we should not be surprised to find that there have been aberrations from scientific method. If the mechanistic basis of many health disturbances has been almost ignored until recent years, neither will it do to employ such a theory upon grounds of purely morphological character; nor is it permissible to attempt the explanation of everything in a manner which, even here, might be termed "chauvinistic". The kinesiology of the framework must be given due consideration and this will involve us in a most complicated study. It is a study for which the fewest surgeons are qualified. It is alluring to make interesting morphological observations fit into a clinical picture, but it is very important to avoid the great error of unscientific method,—the error of trying to make our findings fit in with preconceived notions. It is a mistake which Bacon, himself, committed upon occasion. Having projected a new (an inductive) method of philosophical reasoning, he did not hesitate to abandon it incontinently when it seemed to his advantage. To study the mechanism of the body with a purpose primarily utilitarian, to investigate with the ultimate purpose of proving thereby something which one had previously settled in his own mind, this is un-

scientific. I need not say here that it is liable to lead one into error, and afterward to give the appearance of having followed a delusion. It is, by no means, always easy to avoid.

THE WORLD WAR AND ORTHOPAEDIC SURGERY

The World War had a great influence upon Orthopaedic Surgery, especially in Great Britain and in the United States. There need be no attempt to deny that the orthopaedic surgeons of the United States had to have some of their early enthusiasm dampened by learning that the rôle which they were to play was not that which they had, at first, conceived it to be, even as they had afterward the opportunity to learn that their place in the whole scheme of rehabilitation was not permitted to become what it might and should have been. But it did become necessary for the general surgeons to acknowledge that here was a group the most of whom were surgeons equal to themselves, even though they were smaller in number and had a differing view-point. The general surgeon came to appreciate, perhaps not too willingly, that this group had accomplishments which were very valuable and which were not his, nor in his ken. "Splint them where they lie!" became a watchword in the treatment of the most serious of war fractures. It was an orthopaedic contribution which did more than to improve fracture treatment. It had an undeniable effect in reducing mortality, as may be shown convincingly by the records. On the other hand, by reason of the wider contacts which military experience brought to orthopaedic surgeons, reciprocal relationships with their colleagues, of more intimate nature than civil life had furnished, were established; perhaps with professional problems more significant than those which had previously been posed to them. They returned from military to civil life with their own professional concepts greatly expanded. It seems fair to say that very few of them resumed their civil occupations without profound alteration in their attitude toward their professional activities and toward their colleagues. One can hardly resist inquiring whether the archaic institution of war was necessary to develop a balance in such relationships? And if war experience produced some such beneficence in addition to its horrors and the brutalization of men without recompense, wherein lay the element of good and how can this same factor be found in time of peace? I cannot resist the feeling that the thrust into the background of the element of economic competition played a significant part, even though I am not expecting everyone to agree with me when I say it. This is not to be taken as an argument against economic competition, since I am a sincere believer in its importance,—an importance which I think it will continue to have until people come into the world with their natural endowment equalized, or their human nature sublimated. I shall not follow the inclination to carry further an economic discussion—I know my incompetence. This inclination is but the expression of the belief that, when the economic element assumes predominance in any medical mind, the professional ideal

is almost bound to sink in proportionate degree and the approach toward being a time-server becomes dangerous.

SIR ROBERT JONES

Nowhere in this discourse would there be a better place to make acknowledgment of our debt to that great man in whose memory this lecture is given. Known to his compeers of all nations for his remarkable personal qualities, as well as his high professional attainments, long before the World War, it was the War nevertheless which gave to Sir Robert Jones his greatest opportunity. It is equally true that, of all men, he was the one to whom it should have come. It was a generous fate that would have it so. For, in respect of professional accomplishment and executive ability, together with a native tactfulness, geniality, and kindness of spirit which served to magnify greatly the potency of these primary qualities, he had no equal. I cannot forget a conversation with him on a beautiful moonlit night in the summer of 1908. Sitting in the park adjacent to his home in Liverpool, he did not hesitate to give expression to his breadth of view in professional matters and to make plainly evident that utmost catholicity of spirit which was his. All homage to him!

THE SOCIAL POINT OF VIEW

From the time when the identity of the orthopaedic surgeon became recognized, the care and the rehabilitation of the cripple has been his particular province. This is true of both the child and the adult cripple. Today, this work constitutes a major activity of social service in most civilized countries. It is easy to understand that this is due in the first place to the efficient service which orthopaedic surgeons have been able to render. It had to become palpably manifest after a time, but this is by no means enough to say. A definite struggle had to be made, to begin with, in order to obtain opportunities to show what could be done for these beneficiaries, and a public interest had to be developed if effective work was to be done upon a sufficiently large scale. In undertakings of this kind, it is usual that, after something tangible has been accomplished, the results are published in order to secure augmentation of financial resources. In such publications one usually finds a sentence or a paragraph making mention of "the devoted service which the orthopaedic surgeons have given". The fact is that, in every country which has developed facilities for the aid of indigent cripples, the orthopaedic surgeon will be found in the background, first winning respect by excellent professional accomplishment. Afterward, he has often exhibited the quality of leadership in gaining the cohesion of his colleagues, as well as the adhesion of a socially-minded lay group. Willingness to avoid personal publicity is but another evidence of sincerity of purpose and of true leadership. Nowhere has this been better shown than in the United States; the State has been led to acknowledge its solicitude and responsibility by numerous legislative enactments. First and foremost, we encounter the name of Dr.

Arthur J. Gillette, of St. Paul, Minnesota, who was able to secure the first of such legislative response in the establishment of the Minnesota State Hospital for Crippled Children, in 1887. To him there is due this expression of praise and gratitude, whether or not we find ourselves in agreement that this is the best way of solving the problem. Orthopaedic hospitals, in some number, there had been before this time. They, too, owed their founding to the same kind of foresight and leadership, but they were supported privately, and were located principally in metropolitan centers, and they responded chiefly to local needs. In 1915, Dr. Michael Hoke secured the interest of the local Scottish Rite Masonic fraternity and the consequent organization of its Hospital for Crippled Children at Decatur, Georgia. Following this, there have been fruitful interest and action on the part of numerous lay organizations, be they of fraternal or of purely philanthropic nature. Tribute must here be paid to Mr. Edgar F. Allen, of Elyria, Ohio. Through his devotion and unceasing effort there was organized the Ohio Society for Crippled Children and afterward the International Society for Crippled Children, Inc. With the support of the Rotarian organization, Mr. Allen succeeded in having enacted by the Ohio legislature the first provision in the United States for a state-wide organization in behalf of indigent crippled children. This has been looked to as a model for similar plans in other states. There followed the organization of the Shriner's Hospitals by this society of Masons. Other laymen have been effectively active in behalf of the crippled and disabled; worthy of especial mention is Mr. Douglas C. McMurtrie of New York. It is surely pardonable, however, if we here revert to the fact that practically all of this admirable accomplishment may be basically credited to that which Orthopaedic Surgery has made possible, as demonstrated by the unselfish work of its votaries. Today we witness the recognition of its importance in the specialized inclusion of the cause of crippled children in the Social Security Act of Congress and the precedent powerful and sympathetic interest of President Franklin D. Roosevelt. In other countries, similar things have been going on. As a motivating force we always find the orthopaedic surgeon. One may not fail to mention the name of Sir Robert Jones in Great Britain, and Hoffa and Biesalski in Germany. While only the leaders have been mentioned by name, it is evident that Orthopaedic Surgery has become an important force in human salvage and one which today's civilization will not consent to relinquish.

CONCLUSIONS

I am convinced that Orthopaedic Surgery represents today a development which is desirable and needful, for the good of humanity. It calls for a high degree of specialized training, both of a scientific and of a practical nature. It demands talent and personal devotion both in kind and amount such as will justify men who possess them to dedicate their lives to this work with the assurance that in so doing there may accrue to them the most ample satisfactions. Orthopaedic Surgery is in its essence a

combination of the mechanical and the operative in surgery, but in its quintessence it is and must continue to be surgery. A proper blending of these two factors is required if we would avoid unfulfilment on the one hand or the infliction of harm on the other. If Orthopaedic Surgery was originally too much concerned with the external use of mechanical appliances, this was largely so because operative surgery had come to be noxious and even destructive in its definitive effects and in this particular sphere. It is not surprising that a movement to the opposite extreme ensued. Today, we find it necessary to be armed with all resources, both operative and non-operative, as well as to know how to mingle them skilfully as regards time and manner. The emphasis of Orthopaedic Surgery today is upon the mechanism of the body's motor apparatus, and what may be done with it and for it. It must be possible to employ such means as will be to the greatest advantage of the patient, be they operative, or non-operative. Orthopaedic Surgery has made valuable contributions to knowledge in its field, both in regard to the normal and pathological physiology of the motor apparatus and in respect to the employment of non-operative and operative methods of help. It has a mission to accomplish much more. For this, ample encouragement and opportunity must be afforded. It is necessary that Orthopaedic Surgery be taught to undergraduate students as a discipline in Surgery, just as Gynecology and Urology are taught. Its teachers should have appropriate academic recognition, as befits their accomplishments and proper functions. While this should imply dignified rank, this cannot be specified. Academic position must depend largely upon a personal and individual factor. However, it should be held that the place of Orthopaedic Surgery in the curriculum may not depend upon the opinion or the whim of any man. Happily, it seems unlikely that the demand will be made that it do so. The place which Orthopaedic Surgery has been able to assume, both in its professional and general social relationships, is dependent upon an idealistic attitude on the part of a great number of practitioners and upon their effective service. It must be assumed possible for the general surgeon who is a skilful operator to learn to do the most difficult orthopaedic operations in an acceptable manner; just as it is possible for a well-trained orthopaedic surgeon to accomplish the same thing in the case of abdominal or other operative measures which are granted to belong within the realm of general surgery. Certainly, the financial consideration should never be the factor to decide what shall be done. However, he who enters the orthopaedic field upon occasion only is likely to misconceive the place of operations in the scheme of things which the orthopaedic patient requires, just as he is unlikely to be provided with the training, the routine, the organized personnel, and the armamentarium which will enable him to do full justice to those who require this kind of service. While many persons still live under such conditions as make it imperative for them to forego highly specialized service in many departments of Medicine and Surgery, the standards of our time call for a large number of

able and well-trained men who are thoroughly equipped in the fund mentals of General Medicine and Surgery, but who devote their lives the practice of Orthopaedic Surgery. Nothing less will fulfil the needs our present-day society; nothing less will answer its demands acceptabl

Doubtless, many of you have had pleasure and profit from the rea ing of Stephen Paget's "*Confessio Medici*" and it is likely that you hav been touched, as I have been, by his concluding words. I beg permissi to repeat them: "He has not fulfilled his ambition to be at the top of th tree; but he can still congratulate himself that he is on a branch. Tl natural dignity of our work, its unembarrassed kindness, its insight int life, its hold on science—for these privileges, and for all that they brin with them, up and up, high over the top of the tree, the very heaver open, preaching thankfulness. Circle above circle, the reasons for it a established, out of the reach of words." This was an expression of th author, having in mind the practice of the medical profession generall I became acquainted with these words quite long ago and they have r mained fixed in my mind with an appeal of indefinable strength. Mor remarkable sentences than these are to be found in this charming book but these closing words impress me with their appositeness, not simpl in respect of our common profession, but particularly to that part of it t which my own career has been dedicated. I commend these words t the thought of every orthopaedic surgeon. They might well conclude hi testament.

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GENERALIZED OSTEOCHONDRODYSTROPHY

The Eccentrochondroplastic Form

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That there exists a great need for a systematic grouping or classification of the various chondrodystrophies and osteochondrodystrophies is apparent to any one who grapples with the problems of diagnosis.

A classification of these conditions suggested by Henry L. Jaffe, pathologist at the Hospital for Joint Diseases, distinguishes true clinical forms corresponding to pathological entities and serves to clarify the problem considerably. It also seems to be of inestimable value in the roentgenographic analysis of these diseases.

According to Jaffe, the osteochondrodystrophies may be divided into two main groups: (A) the localized and (B) the generalized. The localized are neither congenital nor hereditary; furthermore, their onset is preceded by apparently normal development of the region or regions which subsequently become affected. On the other hand, the generalized osteochondrodystrophies are hereditary, and clearly show a predilection for certain families. They begin to make their appearance very early in life and may even be congenital.

The two main groups of osteochondrodystrophies may be subdivided as follows:

A. Localized osteochondrodystrophy
   1. limited to one epiphysis (as Legg-Perthes disease of the capital femoral epiphysis)
   2. limited to one epiphysioid bone* (as Köhler's disease of the tarsal scaphoid)
   3. limited to a few epiphyses or epiphysioid bones
      a. involvement of both capital femoral epiphyses
      b. involvement of more than one vertebral center, or
      c. involvement of one or more epiphyses together with one or more epiphysioid bones.

B. Generalized osteochondrodystrophy
   1. leading to dwarfism because of failure of growth of cartilages (achondroplasia)
   2. leading to the appearance of osteochondromata at the metaphyses, with distortion of the growth region of the bone (dyschondroplasia)
   3. associated with irregular development of epiphyses and epiphysioid structures (eccentrochondroplasia).

* Carpal and tarsal bones which develop like epiphyses from centers of ossification.

By the adjective "eccentro", Jaffe refers to the fact that the epiphysis or epiphysioid bone in eccentrochondroplasia does not develop from a central nucleus of ossification, but from the multiple eccentric centers of ossification so clearly shown in the roentgenograms. Thus the term "eccentrochondroplasia" has been coined not to add to the already overburdened nomenclature, but to make clear the distinction between achondroplasia, dyschondroplasia, and this third form of generalized osteochondrodystrophy (the subject of this paper), which is a separate entity and not a "*forme fruste*" of either or of both of the others.

However, in regard to the generalized osteochondrodystrophies, it must be recognized that mixed forms (wrongly classified as "*formes frustes*") occur, as for instance when the bones of an upper extremity show both achondroplastic and dyschondroplastic features. Furthermore, dyschondroplasia may be unilateral.

LITERATURE

In 1925 and 1926 Silfverskiöld reported two instances of a bone dystrophy which occurred in a mother and in her son, in whom the epiphyseal cartilages were deformed and the ossification was irregular. He classified the condition as a "*forme fruste*" of chondrodystrophy with malacic bone changes. In one case he considered the malacic changes to be of the Calvé-Legg-Perthes type.

FIG. 1

Case 7. Patient, aged five, showing attitude and deformities. The standing height is 38 inches as compared with 44 inches which is the normal height for a boy of this age. This dwarfism is largely due to a shortened trunk; the sitting height is four-fifths of the normal measurements for his age.

The head is normal; the neck is short. The chest has a definite pigeon-breast deformity. The marked kyphosis of the lower thoracic region further increases the anteroposterior diameter of the chest. The abdomen is slightly protuberant. The elbows and wrist areas are enlarged. There is marked general muscular and ligamentous hypotonia, although to a lesser extent than in the older brother. The coxa vara, the genu valgum, and the pes planus contribute to the waddling gait.

Grudzinski (1928) subsequently described what is obviously the same disturbance as a "new disease related to chondrodystrophia foetalis". He divided the atypical forms of achondroplasia into three groups: (1) partial, (2) abortive, and (3) clinically variable. In the third group he placed the cases described by Silfverskiöld in which there were some of the signs of achondroplasia, but in which the bone changes resembled the disease known as "osteochondritis deformans juvenilis". In two of his three cases the disease was generalized, while in the third the changes were localized to both arms. Grudzinski was of the opinion that these were not cases of atypical achondroplasia, but that they belonged to a separate entity, in some respects similar and related to achondroplasia, but showing the most striking change in the cartilaginous ossification of the epiphysis. He suggested that the condition be termed "osteochondropathia multiplex (Silfverskiöld's disease)".

In 1929, Morquio described a form of familial osseous dystrophy which occurred in four of five children in the same family. He stated that he was unable to find similar cases in the literature available to him. In his report he clearly differentiated this disease from achondroplasia. Since then, this curious disease is frequently associated with his name. Most of the cases reported in the literature before Morquio's description and after (as for instance those described by Ruggles, Meyer and Brennemann, Barnett, Davis and Currier, etc.) have been of children and adolescents before the epiphyses had fused; in other words, in the florid stage of the disease when the changes are strikingly characteristic.

OBSERVATIONS

Through the courtesy of two of the author's colleagues it has been made possible for him to study the

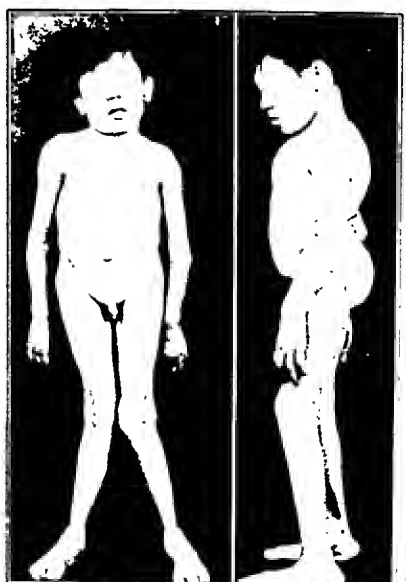

Fig. 2

Fig. 2

Case 6. Patient, aged ten. The characteristic posture and deformities of the chest, the spine, and the extremities are clearly shown. The standing height is 46 inches (that of a normal ten-year-old boy is 59½ inches). The long, narrow face and head rest on a very short, stocky neck. Although the shoulders are narrow, the prominent sternum, the pigeon breast, and the thoracic kyphos increase the anteroposterior diameter of the chest. The chest circumference is 27½ inches (that of a normal boy of ten years is 26½ inches).

The trunk is greatly shortened by the marked kyphosis. The upper extremities are relatively long with large, deformed elbows and flattened wrists. There is a well-developed genu valgum and a marked degree of pes planus. The muscle tone is weak, but there is good muscle coordination. The joints are extremely hypermotile. The hands permit such a pronounced degree of hyperextension as to allow the fingers to touch the forearm. There are none of the outward signs or deformities of achondroplasia.

Fig. 3

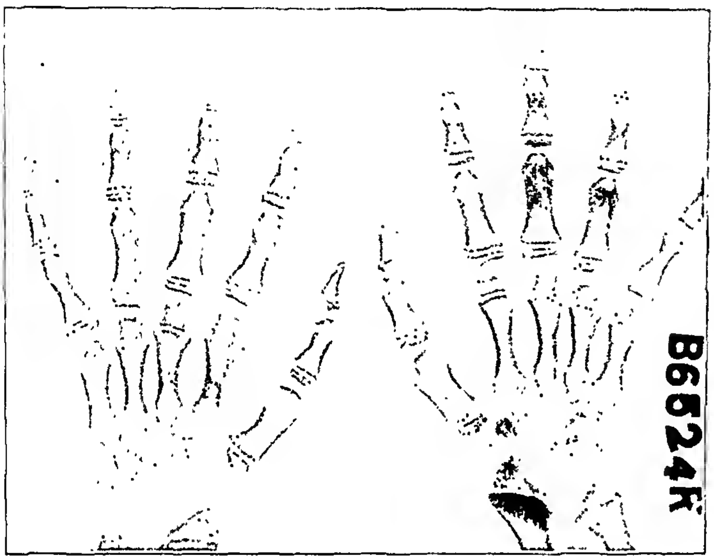

Fig. 4

Fig. 3 and Fig. 4

Mixed type of disease.

In Fig. 3 (Case 7, aged five) the carpal nuclei have a normal aspect and contour, although in Fig. 4 (Case 6, aged ten) they are definitely deformed, but with a somewhat sharp contour. There is fusion of the trapezium and the trapezoid. At the age of ten there is definite delay in the appearance of the scaphoid on the left side.

The nuclei of the heads of the metacarpals are enlarged and, although the epiphyseal surfaces are fairly sharp, the joint surfaces are irregular, due to the presence of minute points of ossification. With the exception of the first metacarpal, the proximal ends are pointed and the axes of the bones are directed toward each other like the ribs of a fan ("*main-en-trident*"). The diaphyses are broad and short with a distinct distal flare. The terminal portions of the terminal phalanges are bulbous.

The juxta-epiphyseal line is clean-cut and sharp and the zone of temporary calcification is a single sharply defined dense line, somewhat irregular, but nevertheless clearly traceable. The ossification of the epiphysis of the lower end of the radius and of the ulna is by punctate centers. The juxta-epiphyseal edge of the diaphysis is convex, and the ulnar and radial surfaces are directed obliquely toward each other as in achondroplasia.

adults of a family in which several children showed the florid changes of the disease in question (which is being classified as eccentrochondroplasia). It has thus become possible to trace the natural history of the disease. As a result of this it would seem that many hitherto unexplainable lesions in the joint ends and certain deformities in the vertebrae in the adult may be the end results of this disease. This form of osteochondrodystrophy apparently goes through several stages,—a latent, a florid, and a stage of healing with its aftermath of deformity.

The cases of Morquio, Ruggles, Brailsford, and others show that this is definitely a hereditary familial affection; that the affected subjects have a definite physical habitus; that the blood of the patients is in no way abnormal; that the disease has no relation to syphilis; and that the changes in the bones are characteristic.

The cases on which this study is based come from two Italian families.

Group I, which the author was permitted to study through the courtesy of Dr. Philip Palew of the Department of Orthopaedics, consists of a mother and six children. The parents were not related. The mother and four children show the changes of the disease.

CASE 1. The mother is fifty-one years of age and is the third child of nine. She is of normal intelligence. Up to the age of twenty-five she had occasional pain in the hips, the knees, and the ankles. At present she is free from all symptoms except an inability to go up and down stairs with ease. She was married at thirty years of age and has had six pregnancies with normal deliveries.

Her first two children were outwardly normal. They were not examined roentgenographically.

CASE 2. The third child, a male, aged nineteen, began to complain of pain in the hips and the knees at the age of four. At this time deformities of the lower extremities were noticed.

CASE 3. The fourth child is a female, aged seventeen. At the age of two it was noted that her gait was peculiar. At the present time she does not suffer pain or disability.

CASES 4 AND 5. The fifth and sixth children were male twins, twelve years old. One child complains of tiring easily and has pain in the hips and the knees after exertion. The other has no complaint except in regard to his gait.

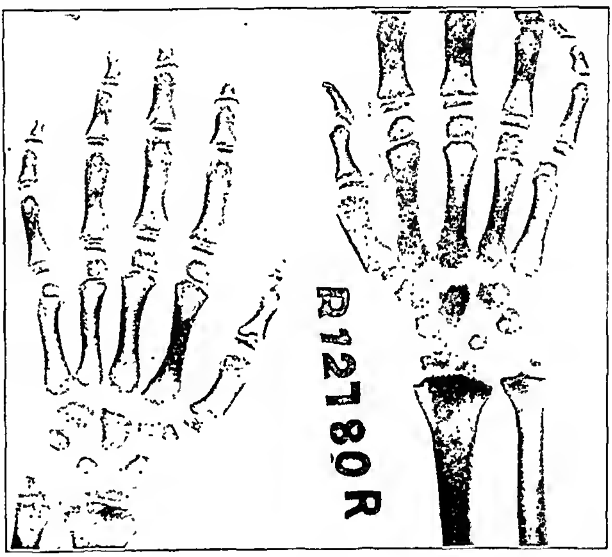

FIG. 5-A FIG. 5-B

Cases 4 and 5. Patients, aged twelve. There is marked irregularity in the contour of the nuclei of ossification of the carpals. The trapezium evidently has two nuclei which are in the process of fusion. A similar condition exists in the scaphoid. Note the notched or scalloped contours particularly of the os magnum. The nuclei for the heads of the metacarpals show a ragged contour with spicule formation. Their bases are not pointed and clear-cut, but ragged and indefinite in contour. The first metacarpal (Fig. 5-B) shows a double nucleated distal epiphysis (Morquio, Ruggles, Brailsford). Instead of being smooth and rounded, the distal ends of the phalanges are irregular and serrated with spurlike projections on the ulnar side. The tips of the terminal phalanges are broadened and bulbous with a coarsely meshed cancellous structure. The epiphysis of the lower end of the radius and of the ulna is an irregularly contoured disc made up of fused punctate nuclei. The juxta-epiphyseal edge of the metaphysis is convex and irregular, due to incompletely *formed*, incompletely cancellated, and crowded lines of temporary calcification.

Through the courtesy of Dr. Rosa Lee Nemir, of the Department of Pediatrics, the writer is permitted to add a second group which consists of two brothers in a family of five children. The parents are in no way related. The family history is negative. There are two boys and a girl who are normal.

CASE 6. This patient is a boy of ten years, born at term with instrumental delivery. The child was born with a "crooked left arm", which was put in a splint by a doctor when the patient was nineteen days old. The arm remained in a splint for six months.

TABLE I

GROUP I

Case	Member	Sex	Age (Years)	Involvement
1	Mother	Female	51	General
	First child	Female	?	?
	Second child	Female	21	None
2	Third child	Male	19	General
3	Fourth child	Female	17	Partial
4	Fifth child	Male	12	General
5	Sixth child	Male	12	General

TABLE II

GROUP II

Case	Member	Sex	Age (Years)	Involvement
	Mother	Female	?	?
6	First child	Male	10	General
	Second child	Male	9	None
	Third child	Male	7	None
7	Fourth child	Male	5	General
	Fifth child	Female	3	None

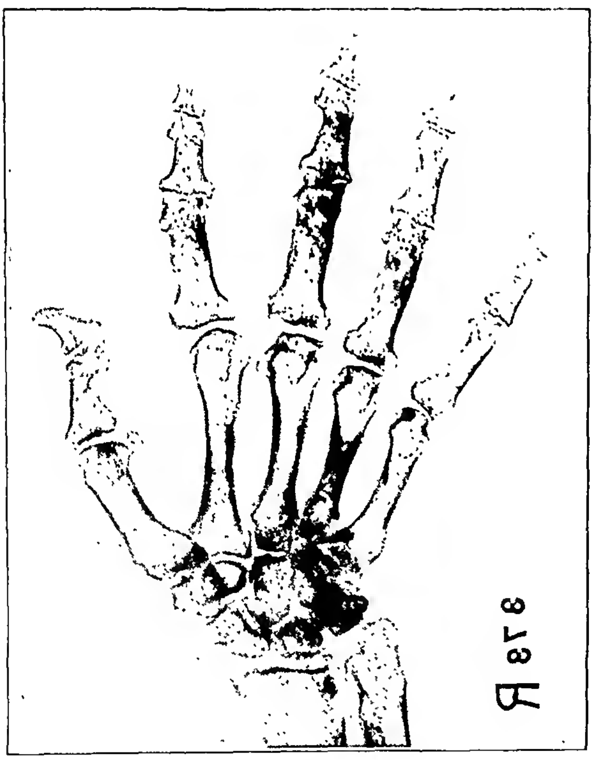

FIG. 6

Case 1. The permanent adult deformity of the hands is seen in the relatively large, deformed, and flattened metacarpals. The short and deformed terminal phalanges of the first finger are a rather constant finding.

Except for this crooked arm, nothing abnormal was noted until the boy was two and one-half years old, when a deformity of the legs was observed. Previously able to walk well, he now began to experience difficulty. Later a bowing of the legs was noted, which grew progressively worse until the age of six. Since then there have been only slight changes. Shortly after this, "pigeon breast" developed. At approximately three and one-half years, a definite kyphos appeared. Finally the arms showed developmental deformities. The mother states that the boy grew rapidly as a baby, but after these deformities appeared he seemed to grow shorter instead of taller, and since five years of age he has not grown in height.

CASE 7. This boy was five years old when first seen in 1932 and was the fourth child in a family of five. He was born at term, after a normal delivery without instrumentation. He showed no signs of birth injury. At seven months a de-

FIG. 7-A FIG. 7-B FIG. 7-C

Cases 4 and 5. The tarsal bones are very markedly deformed and osteoporotic. The contours are extremely irregular with crenations, indentations, and spicule formations. The proximal ends of the metatarsals are irregularly flattened without any sharp contour. The diaphyses are of normal length, the distal ends being somewhat crenated. There are several pin-point nuclei of calcification in the cartilage at the head of the first metatarsal bone (Fig. 7-A). The terminal tufts of the phalanges are pointed.

formity of the back was noted, and a back brace was applied for six months without improvement. At three years the child developed a deformity of the legs which has progressed to the present time. The mother thought that the child had grown normally in height until recently.

The disease is not generally recognized until the child begins to walk, although the characteristic roentgenographic signs become apparent with the onset of ossification of the epiphyseal cartilages. The disease is self-limited. The florid stage (even without treatment) gives way to a healing stage. The outward deformities which may have developed gradually become less marked with the approach of puberty, and in the adult no outward evidences of the disease except the genu valgum and pes planus are apparent.

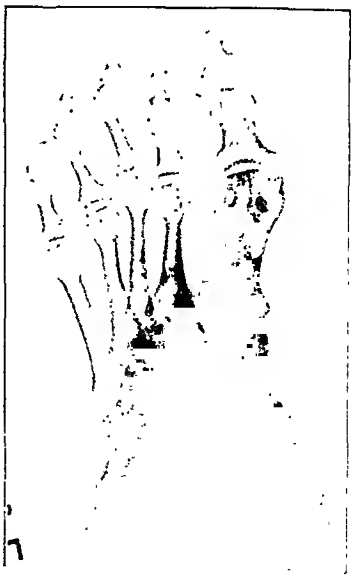

FIG. 8

Case 1. Adult lesion. Note the enlargement of the heads of the metatarsals and the flattening of the distal ends.

Outward Signs

The most striking outward deformity

FIG. 13

Case 2. The permanent deformity is also shown as a flattening of the astragalus associated with a shallow tibial mortise.

to rest on the thorax, so that the chin extends over the sternum. The pelvis is tipped forward. The hips are thrown back, the thighs are bent forward, and the legs are flexed on the thighs and are in the position of extreme genu valgum. The feet are flat and everted. The hands have the trident form. The fingers are short and stubby and have a tendency toward lateral deviation. With the arms at the side, the fingers reach almost to the knees. There is an apparent enlargement of the extremities at the joints and a peculiar laxity and hypermobility.

Because of the knock-knee, the flat-foot, and the malformation of the vertebral column, the gait resembles that of one affected with congenital dislocation of the hips.

The genitals are normal. The intelligence is normal. The reflexes are normal. The blood Wassermann, sugar, calcium, and phosphorus are, as a rule, normal.

Roentgenographic Changes

The characteristic feature of the disease is a peculiar disturbance in epiphyseal ossification associated with a malacia, which produces a definite deformity in the size and the shape of the bones, particularly in the articulating ends.

Florid Stage

The most striking changes of this stage are shown in the ossification zones. The changes usually involve all of the bones, including the vertebrae, with the exception of the flat bones of the skull. However, as in all types of generalized dyschondroplasia, the changes may not involve all of the bones to the same extent and there are cases where only a few bones are involved.

The mixed type, modified by certain achondroplastic characteristics, is apparently not uncommon. The individual bone ends have shapes

FIG. 14-A FIG. 14-B FIG. 14-C

Cases 4 and 5. The ossification of the epiphyseal cartilage by means of punctate nuclei in the outer and posterior surface of the femoral epiphysis is also shown very distinctly in the outer tibial epiphyses. The line of temporary ossification of the diaphysis is thinner than normal and irregular. The outer and upper portions of the patella show the same mode of ossification. The epiphyseal bony nucleus for the tuberosity of the tibia is not present.

The epiphysis for the upper end of the tibia is markedly pyramidal, with coarsened trabeculae. Numerous lines of temporary ossification are seen in the diaphyses. There is a deep groove-shaped depression over the inner, lateral, and posterior aspects of the tuberosity. The entire head of the tibia is bent backward. As growth proceeds, the ossification of the outer portion of the epiphysis is delayed and its contour is irregularly outlined by numerous fragments of bone.

which resemble the bones of achondroplasia. The general body deformity is, however, not present. No sharp line of demarcation can be drawn between the two types, as far as the underlying eccentrochondroplastic characteristics are concerned, although the intensity of disturbance of the cartilaginous ossification and the changes in bone structure are more marked in the pure cases of this disease. This mixed type has occasioned much perplexity as to its proper place in the classification of the congenital osteochondrodystrophies. As already stated, it was originally designated as a "*forme fruste*" of achondroplasia and even recently Snoke, in an article on chondrodystrophia foetalis, placed a case of this type of eccentrochondroplasia (Case 3) into Kaufmann's classification of achondroplasia (malacic type), where it does not belong.

FIG. 15

Case 1. Adult deformity of the knee joint. Note the flattening of the condyle, the backward extension of the head of the tibia, the coarsened trabeculae, and osteoporosis.

There is an increase in the width

of the cartilage plates. Normally, the cartilage is gradually ossified as a regularly progressive and advancing zone of ossification. In this condition the zone of temporary ossification is irregular in density, its advance is irregular and disorderly, and uneven lines are always left behind, both in the epiphysis and in the diaphysis. Small nuclei of bone are found irregularly distributed through the cartilage. As growth proceeds, these fine points of ossification coalesce, giving the main nucleus a ragged contour both on the epiphyseal side and on the joint side. After complete fusion of these isolated nuclei has taken place, the epiphyseal ends attain a smoother contour. The involved bone ends, however, are left markedly deformed in shape and diminished in size (Figs. 6, 8, 11, 13, 15, and 18).

The malacic changes involve the bone and the cartilage and produce bowing both in the metaphysis and in the epiphysis, resulting in humerus varus, coxa vara, and genu valgum. On the concavity of the bent bone the periosteum is thickened and there is osteophyte production. On the convexity the cortex is thin and porous. The compact tissue is sparse and porous. The cancellated structure is widely meshed and the lamellae are coarse.

There is no marked delay in the first appearance of the centers of ossification, but subsequent growth, fusion, and molding are slow.

The primary nuclei for the carpal and tarsal bones and the secondary nuclei for the epiphysis may appear as multiple pin points of ossification which fuse as growth proceeds, or the nuclei may appear with their usual contours, but become deformed as a result of punctate accretions as the ossification proceeds. (See Figures 3, 4, 5-A, 5-B, 7-A, 7-B, and 7-C.)

Instead of the usual more or less convex contours, the tarsal bones show concave or scalloped, hazy, double contours, to which are fused

FIG. 16

Case 7. The segments of the epiphysis for the upper end of the femur, instead of being hemispherical, are irregularly shaped plates with irregular contours. The epiphysis for the greater trochanter is deformed and irregular in outline. The acetabulum appears to be relatively large, particularly the iliac portion, and relatively shallow. The coxa vara is especially striking. The pelvis is of the anthropoid type. There is marked inward displacement of the acetabula.

small fragments of ossification. Fine spicule or spur formations extend into the cartilages. The cancellated structure is coarse, irregular, and porous. As the age advances, the bones tend to assume their normal anatomical contour, but they are smaller than normal and show definite deformities.

FIG. 17

Case 2. The changes found in the hip joints of the adolescent. The femoral heads are small and flattened. The neck is short and in a position of coxa vara. The acetabulum is relatively large and shallow.

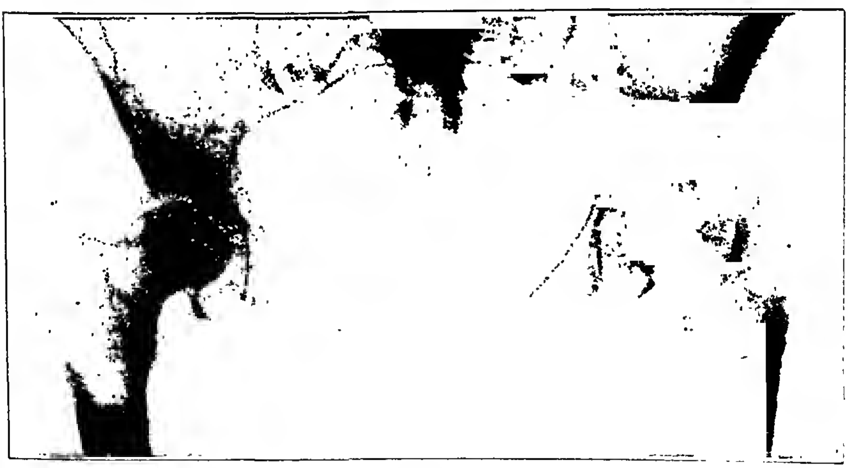

FIG. 18

Case 3. Adult type of lesion. Note the large acetabula and the small femoral heads in coxa-vara position.

The normal shape and sharp contour of the nuclei of ossification of the epiphyses of the long bones are strikingly changed. The irregular punctiform ossification and the spicule formations are responsible for the irregularity in contour.

Characteristic changes are shown in the juxta-epiphyseal ends of the diaphysis. These are usually irregularly flat or convex, never concave. The zone of temporary calcification is wide and ragged or fragmented, and the immediately adjacent zone of

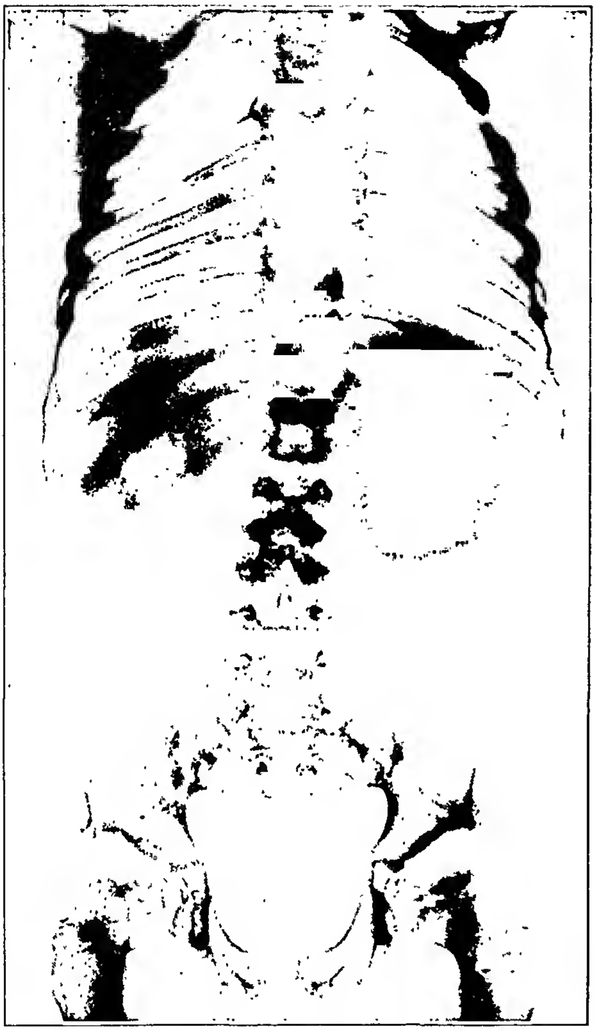

Fig. 19

Fig. 20

Case 7. The vertebral bodies of the thoracic spine show a convexity on both upper and lower surfaces, while the anterior surfaces show a blunted projection which in the lumbar region becomes sharp and pointed. It is in this area that there is the kyphos. The intervertebral discs are enlarged. The ribs are broadened at their cartilaginous ends.

cancellated bone is very coarse and trabeculated and is traversed by incompletely formed residues of unabsorbed lines of calcification.

There is a definite delay in, and in most cases an almost complete absence of, ossification of the rims of the glenoid cavity (Figs. 10 and 11) and of the acetabulum. Even when the lesions are generalized, a single bone, the fibula, may remain free from the characteristic changes. It is to be noted that in chondrodystrophia foetalis the fibula also remains

free from the disease and grows normally, and thus exeeeds the tibia in its length.

In the mixed type of disease, the proximal ends of the metacarpals are pointed and the axes are directed toward the eenter of the earpal area. The distal ends are flaring and flattened. The bones are short and broad. This gives the hand somewhat of the "*main-en-trident*" form (Figs. 3 and 4).

When the intensity of the process is not marked, the diaphyses of the metacarpal and metatarsal bones at the ends devoid of epiphyseal cartilages show striking ehanges. Thus, the proximal ends of the metatarsals are ragged and irregular and have a disordered eaneellated architeeture (Figs. 7-A, 7-B, and 7-C). The distal ends show a peeuliar crenation.

FIG. 21

Case 2. Adolescent type. The vertebrae are flat and wide. The intervertebral discs are widened. There is still a slightly blunted projection from the anterior surface of the vertebrae.

The spinal deformity is striking and charaeteristic (Figs. 19, 20, and 21). The bodies are flattened and the anterior eontours are pointed, beak-shaped, or tongue-shaped along the inferior border. The zones of temporary caleification are dense, and spicules of bone projeet into the cartilaginous plate. The trabeculae of the cancelli are coarse and irregular. The intervertebral discs are wider than normal. The kyphosis is clearly seen to be due to a change in the relationship (wedging) between the lower two thoracic bodies. In spite of this deformity, the spaces in this area are not diminished in size. As growth proceeds, the sharply pointed anterior surface becomes blunted. The segments of the sacrum usually remain unfused.

The skull may be scaphoeephalic or normal. The sella tureica is normal in shape and in size. The accessory sinuses are usually large.

Healing Stage

In the healing stage the tendency to the establishment of the normal arrangement and form is very marked. There is consolidation of the irregular islands of ossification and the surface contour sharpens, but neither the shape nor the size is ever completely normal. The bending and bowing resulting from the malacic changes, whether at the ends of the

bones or in the shafts, persist and the disordered ossification results in defective bone formation. This deviation is sufficiently striking to mark the bone as showing the terminal stage of the disease in the same way as the end result of marked rachitis is recognizable. Thus the ends of the long and the short bones are enlarged and flattened. The spherical heads of the humerus and the femur are deformed and are usually smaller than normal, appearing more so because of the defective neck formation and abnormally large joint space. In the shoulder, the defectively formed, shortened, and flattened head appears to articulate with a glenoid process almost devoid of a glenoid cavity. Roentgenographic examination usually reveals small femoral heads with shortened necks in coxa vara in relatively large acetabula. The deformed and flattened upper contour of the upper surface of the astragalus articulates into a deformed mortise of the tibia. The coarse texture of the cancellated bone persists.

The vertebral bodies become markedly shortened and very wide. This platelloid type of vertebra is not infrequently found in isolated cases as a single lesion and has been described as a developmental aberration. In these cases, other evidences of healed osteochondrodystrophy, when sought for, will be found.

Since in the adult the outward form of the body may no longer present any striking deformity in form or in posture, the deformity of the bones as shown by the roentgenogram has until now not been associated with this disease, but has usually been ascribed to some old inflammatory or dystrophic lesion of the Perthes variety. It is now apparent that such findings should be ascribed to the form of bone and cartilage malacia here described.

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BOUND FEET IN CHINA

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HISTORY

There is considerable difference of opinion as to the origin and history of the practice of foot-binding. A comprehensive discussion on this subject is contained in the works of Yu Cheng-hsieh (1775–1840). The most generally accepted belief is that it began with a lady named Yao Niang* in the court of Li Yu, King of Southern Tang, a great poet but a poor ruler, who reigned from 961 A.D. until he surrendered to the victorious army of Sung in 975 A.D. This view, however, cannot be accepted by critical scholars, because such a difficult and cruel practice, started by a court lady in a small kingdom in the Yangtse valley late in the tenth century, could not possibly have become a fairly general fashion by the next century, and we have indisputable evidence that foot-binding had already been commonly practised in North China by the eleventh century.**

Moreover, we have evidence to show that, as early as the ninth century, the feet of singing and dancing girls had already become quite small. The poet Tu Mu (803–852 A.D.) described a woman entertainer's feet as of "the length of a foot minus a quarter",† which is eighteen and six-tenths centimeters,‡ and as "slender and pointed as bamboo shoots" and "wrapped in embroidered silk". Another poet, Han Wo (who died about 915 A.D.), spoke of a woman's foot as being only six inches in length (which is fourteen and nine-tenths centimeters). In half a century, the length of the feet had been reduced by almost four centimeters. In the same poem, Tu Mu wrote:

"The carefree youths of Chang-an, taking advantage of her drunkenness,
Laughingly took her feet from under her skirts and exhibited them before the flowers."

This clearly indicates the existence of a tendency to play with the feet of women, a tendency which, more than imperial patronage or any other

* Yao Niang's story is found only in writings of the twelfth century. Her name was never mentioned in the two histories of the Southern Tang Dynasty by Ma Ling and Lu Yu, nor in any other works on that kingdom by contemporary witnesses.

** The poet and scholar Hsu Chi (1028–1103) wrote apologetically of a pious woman who, because of the necessity of doing hard work, "had no time to bind her feet".

† The line may be read in two ways. This reading follows the suggestion of Yu Cheng-hsieh, who held that in all ancient writings "*ssu fen*" always meant one-quarter. However, "*ssu fen*" may also mean four-tenths, in which case the length of the feet would be six inches,—that is, fourteen and nine-tenths centimeters.

‡ The calculations of the foot measure of the Tang Dynasty given here are based on "A Study of the Weights and Measures" by Wu Ta Cheng (1835–1902). One Tang inch is about two and five-tenths centimeters.

thing, was the real origin of foot-binding. In another poem, Tu Mu had these lines:

"You may allow other people to look at your dancing shoes,
But your smiles are reserved for me alone."

It seems probable that the solo dancers were the first women to have pointed shoes and to dance sometimes on tiptoes, from which have gradually come all of the excesses of the bound feet.

It is now quite impossible to assign dates to the early beginnings of this practice. Ssu-ma Chien (145–85 ? B.C.) described the dancers of his time as having long sleeves and pointed slippers, but it was not until the ninth century that we have clear evidence that the feet were already very small, and they rapidly became smaller and smaller in the subsequent centuries. Official records show that, at least during the earlier period of the Tang Dynasty (618–906 A.D.), this practice, which originated with dancers and public entertainers, was not yet adopted by the women of the Court and of the higher families.* In a country where there was no permanent aristocratic class, the fashions invariably came not from above, but from below; and the practice of foot-binding soon spread in North China and invaded even the best and highest families. It is recorded that the ladies of the Imperial Household in the eleventh century had bound feet.[9]

TECHNIQUE

In general, it may be stated that the technique used in producing bound feet is the reverse of that which is employed by the modern surgeon in correcting deformities such as those found in club feet. In either instance, the process requires a long course of bandaging, during which time the natural growth changes allow the feet to become reshaped according to their new confines. The process of binding the feet is started some time between the fourth and eighth years of life, usually about the sixth year, and is continued throughout the entire life of the individual. Should the parents be wealthy, the bandage may be of silk or of other costly material. Among the lower classes, strips of ordinary cotton cloth are employed, each measuring about three to five feet in length and from two to three inches in width. The number and size of the strips vary according to the size of the feet and the amount of tension which is exerted. Usually two to four bandages suffice for each foot. The first stage of the process begins with severe kneading and manipulation of the feet. The four outer toes are flexed upon the sole and are held in that position, the great toe being the only one allowed to project in its normal extended position. The metatarsals are pressed together as the bandages are applied. In spite of the pain after each kneading, the girl is forced to walk, in order to help reestablish the circulation. Following repeated manipulations and bandagings, over the course of approximately a year, the four outer toes are

* See Yu Cheng-hsieh, who based his conclusions on descriptions of shoes of Court ladies, which are found in the "History of Tang Dynasty" by Liu Hsu.

FIG. 1

Roentgenogram of a Chinese bound foot. Note the almost vertical position of the calcaneum and of the outer metatarsals.

successfully contracted against the sole, and the forefeet show marked narrowing. Then, during the next two or three years, the second stage of the manipulation and binding is vigorously carried out. The feet are kneaded and manipulated, so that they become flexed upon themselves through the mediotarsal joints. After each treatment, the feet are held in the new position with bandages applied in the figure-of-eight manner. Once the feet are reduced to the desired form and size, the various layers of bandage are sewed together and act as a substitute for a cast. This is changed at intervals of several months. At times, tightly fitting inelastic socks are worn for the same purpose.

Among the wealthy classes, technicians are called into the home to perform the foot-binding; among the poorer classes one of the members of the family does the work. By the age of eleven or twelve, the girl usually acquires the art of applying her own bandages. Finally, she begins to appreciate the social value and the beauty of her small feet, and she speaks proudly of them to her companions. Unless performed by gentle or experienced hands, the process is associated with great pain and discomfort to the girl. Among the poorer classes the mother may be inexperienced in bandaging and therefore there is great danger of complications, especially those which follow disturbances of the circulation. Later on in life, it is necessary to continue the bandaging indefinitely, since unbound feet become painful. If the bandages are removed, the feet lose their habitual support and strain of the ligaments and swelling of the soft tissues follow.

EFFECTS OF FOOT-BINDING

The anatomical changes to be observed in dissecting bound feet are quite distinct (Fig. 1). The outstanding changes are: (1) an approximation of the metatarsal heads to the posterior portion of the os calcis; (2) a change in the long axis of the os calcis from a horizontal plane to a vertical one, or even beyond the vertical so that an actual calcaneus deformity is produced; (3) a wedge-shaped deformity of the scaphoid, cuneiform, and cuboid bones; and (4) flexion deformities of the four outer toes. All bony and soft structures of the foot show marked atrophy. The intrinsic

muscles are usually reduced to small fibrous bands. As a consequence of the shortening and angulation of the foot, the height of the long arches is greatly increased and there is a furrow (Fig. 2), sometimes as deep as two inches, in the soft tissues of the sole of the foot, below the mediotarsal joint. There is extensive associated atrophy of all the muscles of the leg. The muscles of the thigh usually show a mild compensatory hypertrophy (Fig. 3), but this is probably more apparent than real. Since the os calcis lies in a vertical position, its long axis is continuous with that of the tibia and its posterior surface, where the tendo achillis is attached, becomes the inferior surface on which the weight of the body is sustained. If a complete calcaneus deformity is not present, the other points of support on the plantar surface of the foot are the distal end of the first metatarsal bone and the once extensor surface of the four outer toes. As a consequence of prolonged immobilization, the tarsal and tarsometatarsal joints show marked fibrous ankylosis. Movements of the ankle joint and of the great-toe joint are fairly well preserved.

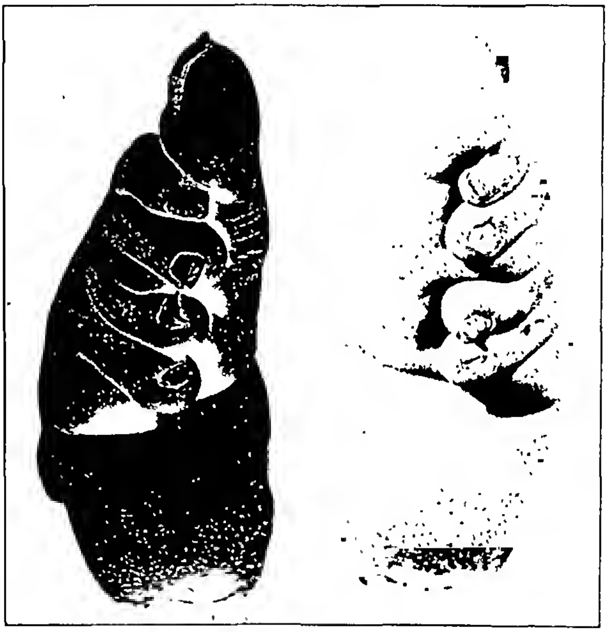

Fig. 2

Plantar view of Chinese bound feet, showing characteristic deformity. Note the deep transverse crease beneath the mediotarsal joints, also the four outer toes which are completely flexed against the soles of the feet.

In an effort to determine any possible effects of the deformity upon the other parts of the skeleton, a complete roentgenographic study of all bones of the lower half of the body was made in six cases. All the findings were normal except for slight atrophy of the bones of the legs. The tibiae and fibulae were normal in density and in length, but slightly smaller than normal in circumference,—a change probably related or due to the associated atrophy of the muscles of the legs.

The ill effects of foot-binding may be classified under two headings: (1) those due to circulatory interference and infection of the tissues; and (2) those caused by weakening of the bones and ligaments. Almost every woman with bound feet suffers, at one time or another, from one of these conditions. During the process of binding, ulcers are often produced and

Fig. 3

Photograph of a Chinese woman with feet bound only to a moderate size. Note the atrophy of the feet and legs and the apparent hypertrophy of the thighs.

occasionally, in neglected cases with severe infection, the condition may go on to gangrene. The extent of impairment of walking is usually determined by the size of the feet. If the feet are bound to only a moderate size (from five to six inches in length) the woman usually gets along very well. If the feet are bound to a very small size (from three to four inches in length), walking and particularly running are greatly interfered with, the latter becoming practically impossible. (See Figure 4.) There is complete loss of elasticity of the gait, and therefore the spine is subjected to constant jarring upon any attempt to hurry. Occasionally one sees patients with static arch strain and also with corns and calluses, but the actual incidence of these conditions is probably no greater than that in normal feet. Apparently, binding does not predispose the feet to chronic arthritis or chronic bone diseases such as osteomyelitis or tuberculosis.

The evil effects of foot-binding have been realized by various of the past rulers of China. In the Manchu Dynasty (1680–1911 A.D.) an attempt to prohibit foot-binding was made by Kang Hsi. Chien Lung (1736–1790 A.D.) issued definite orders that all foot-binding among women must be stopped. These efforts did to some extent restrain this custom, but did not entirely control it. It was not until the overthrow of the recent Manchu Dynasty in 1911 that the governmental authorities were able to exert effective legislation against this practice. Fortunately, since that time, bound feet are rapidly disappearing from the eastern provinces of China. In many of the interior or western provinces where extreme conservatism still exists, and where the number of modern educated families is too small to exert any

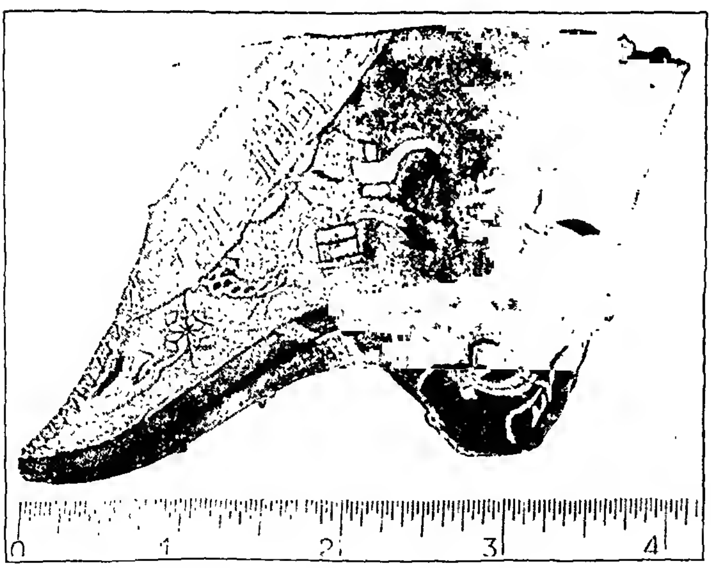

Fig. 4

Photograph of a shoe worn on an unusually small bound foot.

influence upon the communities in which they live, foot-binding is still performed. Should China keep up its present stage of progress in education, the custom will probably become obsolete within the next two or three decades.

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THE EFFECT OF THE PERIOSTEUM ON FRACTURE FRAGMENTS*

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This paper is not concerned at all with the effect of the periosteum on the union of fractures or with its power to reproduce bone; it deals only with the mechanical effect of the periosteum either in assisting or in hindering proper reduction of a fractured bone.

Very little attention has been paid to the periosteum in this respect. Most of the difficulty in the reduction and the retention of fractures has been ascribed to the pull of the muscles on the bone fragments. Probably the muscles are the major factor in producing displacement, at least after the fracturing force has ceased to act, yet we have some experimental evidence that the periosteum may be a marked factor in preventing reduction. Ollier[2] in 1867 recognized the fact that the periosteum is not completely torn in fractures, but a portion remains intact, forming what he described as a periosteal bridge which he considered only from the viewpoint of the healing of the fracture.

Some ten years ago, the writer began a series of simple experiments which yielded some surprising results as to the mechanical effect of the periosteum on fresh fractures[1]. Since that time, other experiments have been made along the same line, and attempts have been made to apply the results clinically in order to check them in actual practice. The bones used have been obtained from one of the packing companies and fractured. In these bones the muscles and tendons were removed, but the periosteum was left intact. Various types of bones have been so studied,—beef and calf femora, humeri, tibiae, fibulae, and shank bones. These bones were all fresh,—that is, in each case the animal was alive less than twenty minutes before the bone was obtained. They were all from young or young adult animals. The bones were fractured in various ways and a wide variation in the types of fractures was noted. Also there was a wide variety of injuries to the periosteum.

Bone of course follows the general law of fracture of any other material,—that is, it bends with a compressive force on the concave side and with a stretching force on the convex, until the limit of elasticity is reached and fracture occurs. The fracture tends to be transverse, but variations occur, probably influenced by the grain of the bone and by the direction of the breaking force.

In general, transverse fractures produced the greatest effect as far as rupture of the periosteum was concerned. The periosteum was never torn completely, but a transverse tear usually was produced on the side opposite the fracturing force and close to the line of the fracture. This

* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons, Cleveland, Ohio, January 14, 1937.

transverse tear involved from one-third to three-quarters of the circumference of the bone. The torn periosteum adjoining the fracture was not stripped from the bone, but the intact portion was always stripped to a considerable extent. This stripping was probably due mainly to the displacement of the fragments, which usually followed the actual fracture of the bone. When the bones were examined following the fracture, the feeling of elasticity in the intact strip of periosteum was quite striking. The elasticity was not great in extent, but it was definite. When the fragments of the bone were placed with the edges together under the intact periosteum and the bone was straightened, this elasticity of the periosteum caused the bone to snap straight, and the impact could easily be felt. This, of course, is the basis for the well-known fact that a fracture may often be more easily reduced by first increasing before correcting the deformity. When a relatively smooth transverse fracture with an overlapping deformity resulted, it was possible to stretch the periosteal bridge by hand traction exerted in the direction of the axis of the bone enough to secure good reduction. However, if there was even a moderate irregularity of the bone ends in an overlapping deformity, it was very difficult and frequently impossible to reduce the fracture by traction. The periosteum was not elastic enough to allow the irregularities to slip by and so the pull had a locking effect. To test the amount of pull necessary to overcome this, a stretching apparatus with a spring balance was made to determine the force exerted in overcoming this locking effect. In most cases it was found that the only force which was able to do this was one which would cause rupture of the periosteum. The force necessary for this was from fifty to sixty pounds. In cases where traction did not cause reduction the periosteum usually began to rupture at about this pressure. Rupture was not sudden, but consisted of a gradual slipping of the fibers.

When a long diagonal or comminuted fracture was produced, the periosteal injury was very different. Outwardly it was always much less in degree. The injury in these cases was never a transverse tear, but a longitudinal slit near the pointed end of one of the fragments. If there was much comminution of the bone there was frequently no injury to the periosteum unless there was a very marked displacement of one of the fragments. In either of these types, when the periosteum was opened, it was found widely stripped from the bone; often the entire circumference of the bone for the length of the fracture was denuded of periosteum. In other words, the periosteum remained as a practically intact tube. In this type of injury, traction on the ends of the bone gave the same feeling of elasticity noted before and good reduction was obtained unless it was prevented by the malposition of a comminuted fragment. The tube of periosteum, under traction, acted as a splint to maintain the reduction.

Spiral fractures were produced rather uncommonly, but they did occur even when the bone was broken by impact alone. In this type the fracture is really a long diagonal one with a rotational displacement of the

fragments. The periosteal injury in these cases was a combination of a tear and splitting. The torn portion was diagonal with a split extending longitudinally from the upper end of the tear. There was considerable stripping of the periosteum from the fragment which rotated. This type of fracture was not reduced at all by straight traction but was easily reduced by reversing the rotation of the fragment. However, the split edges of the periosteum practically always folded in, so that they were caught between the edges of the bone on reduction. This was the only type of fracture in which this regularly occurred.

This observation brings up the question as to inclusion of soft tissues between the bone ends. The untorn bridge of periosteum, which covers a half or a third of the circumference of the bone in transverse fractures, of course prevents any intrusion from that side. On the open side, however, it is a different matter, and muscle, fascia, or other tissue could easily be caught by the pinching action of the bone ends. The fate of any tissue so caught is problematic.

Mechanically the bone fragments joined by untorn periosteum form a toggle-joint by which the power is multiplied enormously, so that the pressure on any tissue caught between the ends may easily be subjected to pressures up to several hundred pounds. It is doubtful if any tissue in the body can long withstand any such pressure. This point may be worth further investigation.

Now as to the practical application of these observations,—we do not believe that the periosteum is the only structure at fault in resisting the reduction of fractures of the shafts of long bones, but we do believe that it must be taken into account more than it has been if fractures are to be treated on a thoroughly scientific basis.

The periosteum has enough tensile strength to be much more resistant to reduction by traction than we have believed. Furthermore, it does not tire as do muscles. Nevertheless, it can be torn by a powerful pull, and, when this is done, we have deprived ourselves of the valuable splinting action of the untorn strip of periosteal tissue, to say nothing of its regenerative action in the healing of the fracture.

Therefore, it seems logical to employ the gentler manipulative methods which most of us know, but which have penetrated the text-books to a surprisingly small extent. In most of the text-books with which the author is familiar, "strong traction" is the universal solvent for fractures. Also, with the increasing "gadgetization" of fracture treatment, the "strong traction" is becoming stronger and stronger. There is room for conservatism in pulling and hauling as well as in operative treatment.

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"SCIATICA" CAUSED BY INTERVERTEBRAL-DISC LESIONS

A Report of Forty Cases of Rupture of the Intervertebral Disc Occurring in the Low Lumbar Spine and Causing Pressure on the Cauda Equina

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The syndrome of low-back pain with radiation down the posterior thigh and the posterolateral calf has engaged the attention of the disciples of Aesculapius since the beginnings of the healing art. In more modern times the label of "sciatica" or "lumbago" is often attached by the patient to his disabling condition. "Radiculitis" and "peripheral neuritis" are terms which appeal strongly to the neurologist. The orthopaedic surgeon, on the other hand, has been able to popularize "sacro-iliac" and "lumbosacral joint" or "ligamentous strain". These and other similar diagnostic labels are essentially clinical concepts and have very little laboratory justification for their existence. There is no pathological specimen to examine, the ordinary roentgenogram is usually negative, and the rest of the routine laboratory work seems to shed little light on the situation.

Of the great numbers of patients who have low-back pain and "sciatica", there are a few that show objective pathology adequate to explain the symptoms. A well-marked spondylolisthesis, pelvic tumors (usually malignant) involving the lumbosacral plexus, tumors of the lower lumbar spine involving the cauda equina, all present an adequate cause for sciatica and can be demonstrated objectively at operation or at the autopsy table.

There is a group of cases in which the symptoms are due to pressure of a ruptured or herniated intervertebral disc on the cauda equina. It is only within recent years that intervertebral-disc lesions have been recognized as a cause of low-back pain with "sciatica", and the syndrome has as yet not been clearly described.

It is the purpose of this paper to review rather briefly the development of our knowledge of intervertebral-disc lesions, to report forty verified cases of intervertebral-disc lesions of the lower lumbar spine causing pressure on the cauda equina, to analyze the findings in these cases, and to draw such deductions and conclusions from the data as seem warranted.

HISTORICAL SURVEY

In 1896 Kocher reported a case of rupture of the intervertebral disc. A man, twenty-six years of age, fell from a height of 100 feet, landing in the standing position. He died of internal injuries within a short time. At autopsy he was found to have had a rupture of the disc between the first and second lumbar vertebrae without fracture of the vertebral bodies. The displaced intervertebral-disc tissue had apparently caused no cord damage.

In 1911, Middleton and Teacher reported the case of a man of thirty-eight who felt something "snap" in his back while he was lifting a heavy weight and was unable to straighten up. He had only local pain in his back until that night, when suddenly he felt as if his legs had gone to sleep and he could no longer move them. On physical examination he exhibited a complete flaccid paralysis of the lower extremities with absence of knee and ankle jerks, anaesthesia to the level of Poupart's ligament, and incontinence of urine and faeces. The patient died from urinary infection, and autopsy revealed a mass, one and five-tenths centimeters by five-tenths of a centimeter in size, anterior to the dura with its edges detached and free, at the level of the disc between the twelfth thoracic and the first lumbar vertebrae. There was no injury to the vertebral bodies. The mass was white and firm and "particularly resembled the central pulp of the intervertebral disc".

These two pathologically proved cases represent the first reports of rupture of the intervertebral disc so far as the author can ascertain.

In that same year (1911) Goldthwait reported the case of a patient suffering from a "right sacro-iliac strain", who developed a flaccid paralysis of the legs with disturbance of the genito-urinary system and the rectum, following an ether manipulation to "reduce" the subluxation. The paralysis partially disappeared after the patient had been placed in a good position, but it recurred the following night when the patient moved about unguardedly. Beyond the signs of paraplegia, nothing was found on physical examination except slight tenderness at the lumbosacral junction. A laminectomy was performed by Cushing, who found no lesion of the cauda equina except for "narrowing of the osseous canal at the lumbosacral junction". The patient made a slow partial recovery following the operation. In a detailed discussion of the case, Goldthwait reviewed the various possible causes of the paraplegia. He dismissed tumor, hemorrhage, and spondylolisthesis as possible factors and *concluded* that posterior displacement of the lumbosacral intervertebral disc with pressure on the cauda equina was the logical explanation. He suggested that other cases of paraplegia, lumbago, and "sciatica" might be due to pressure on nerve roots from a displaced intervertebral disc.

Neurological surgeons have recognized for many years that there is a small cartilaginous extradural tumor arising from the intervertebral disc which may cause cord or cauda-equina pressure. In 1923, Ott and Adson reported two such cases and called them fibrochondromata. Again, in 1925, Adson reported an additional case, calling it a cervical extradural ventral chondroma. Veraguth reported a similar case in 1928, calling it a myxochondroma. Stookey described seven cases in detail and discussed the neurological findings. All of his cases were in the cervical region. Elsberg in 1931 reported fifteen such cases in which operations had been performed. He described the symptomatology and the physical and laboratory findings in detail. Histological examination showed the material removed at operation to be practically identical with normal disc

tissue. He concluded that the tumor was benign and that "chondroma" or "ecchondrosis" best described it. Bucy, Bailey and Bucy, and Mixter have reported similar cases.

In 1929 Dandy reported two cases of "loose cartilage" which was detached from the intervertebral disc and caused pressure on the spinal cord. He considered the condition similar to osteochondritis dissecans and felt that it was traumatic in origin in each case.

Von Péchy, Klinge, and Kortzeborn, familiar with Schmorl's work, have each reported a case of Schmorl's nodule (*Knorpelknötchen*) on the posterior aspect of an intervertebral disc, causing spinal-cord pressure.

Three cases of a fibroma or of a fibrocartilaginous nodule arising from an intervertebral disc and causing cauda-equina pressure are reported in the French literature (two by Alajouanine and Petit-Dutaillis, and one by Crouzon, Petit-Dutaillis, and Christophe). The etiology was considered to be trauma.

Galland, and Calvé and Galland have described two instances of paraplegia in cases with severe thoracic kyphosis which they attributed to "retropulsion" of the nucleus pulposus.

In 1934, Peet and Echols reported two cases of "herniation of the nucleus pulposus", one of which was cervical, the other lumbar. In both cases there were signs of pressure on the spinal cord, which was relieved by operation.

In the same year, Mixter and the author of this paper reported nineteen proved cases of rupture of the intervertebral disc with involvement

TABLE I

TERMINOLOGY DESCRIPTIVE OF RUPTURE OF THE INTERVERTEBRAL DISC

Authors	Terminology
Bailey and Bucy Elsberg Stookey Adson and Ott	Intervertebral-disc chondroma Ventral extradural chondroma Ecchondrosis
Veraguth	Myxochondroma
Alajouanine and Petit-Dutaillis Crouzon, Petit-Dutaillis, and Christophe	Fibroma Fibrochondroma
Klinge Kortzeborn von Péchy	Schmorl's nodule (*Knorpelknötchen*)
Mixter and Ayer Mixter and Barr Peet and Echols	Rupture or herniation of the intervertebral disc Herniation of the nucleus pulposus Prolapse of the nucleus pulposus
Dandy	Loose cartilage from the intervertebral disc

of the spinal canal. They called attention to the similarity of chondromata to these lesions. They also noted that in the lumbar region the pressure on one or more roots of the cauda equina caused symptoms very similar to those of low-back strain (sacro-iliac and lumbosacral). Mixter and Ayer, a year later, reported thirty-four cases of "herniation or rupture of the intervertebral disc". The nineteen cases reported by Mixter and Barr were included in this group.

The author believes that the writers mentioned were all describing the same pathological entity which is referred to in this paper as *rupture of the intervertebral disc.*

At the Massachusetts General Hospital, from 1927 to November 1936, fifty-three cases of rupture of the intervertebral disc have been verified by operative removal and histological examination of the material. In nine cases, the lesion was in the cervical region; in three, in the thoracic region; and in forty, in the lumbar region. In the remaining case, the lesion arose from the sacrum, presumably from the remnants of the disc between the first and second sacral segments.

Schmorl and his pupil Andrae noted that in 15 per cent. of spines routinely examined at autopsy there were small nodules (*Knorpelknötchen*) protruding posteriorly from the intervertebral disc into the spinal canal. They occurred more frequently in females (18.7 per cent.) than in males (11.5 per cent.). The nodules were small and Andrae concluded that they ordinarily did not produce clinical symptoms from cord pressure. He discussed trauma, degenerative changes in the annulus fibrosus, and developmental anomalies as possible etiological factors.

Mauric in 1933 published a monograph on the intervertebral disc in which he reviewed the literature to date. In particular he laid stress on the clinical importance of the cases of spinal-cord or cauda-equina pressure from posterior herniation of the disc.

CLINICAL FINDINGS

The signs and symptoms of rupture of an intervertebral disc depend upon the location of the lesion. Cervical and thoracic lesions are excluded from this discussion. *Lesions in the lumbar region produce a characteristic clinical syndrome.*

Forty cases of rupture of an intervertebral disc in the lumbar region, causing pressure on one or more roots of the cauda equina, have been verified by operation at the Massachusetts General Hospital in the period from 1927 to November 1936, and their records have been studied in preparing the data for this paper. (See Tables II, III, IV, and V.)

The fact that twenty cases have been operated upon and verified in a single ten-month period in a general hospital of moderate size suggests that this entity is not particularly rare and that many cases have been overlooked or wrongly diagnosed in the past.

It is interesting to note that in 65 per cent. of the cases the lesion was in the disc between the fourth and fifth lumbar vertebrae and in only 30

TABLE II

INCIDENCE

Year	Verified Cases
1927	1
1930	1
1931	1
1932	5
1933	1
1934	5
1935	6
1936 (to Nov. 1)	20
Total (1927 to 1936)	40

TABLE III

LOCATION OF LESION

Disc Between	Cases
Second and third lumbar	1
Third and fourth lumbar	1
Fourth and fifth lumbar	26
Fifth lumbar and first sacral	12
Total	40

TABLE IV

AGE INCIDENCE

	Years
Youngest	20
Oldest	58
Average	37
Median	36

TABLE V

SEX INCIDENCE

	Cases	Per Cent.
Female	5	12.5
Male	35	87.5
Total	40	100.0

per cent. in the lumbosacral disc. The explanation for this is not clear.

The high incidence of this entity in males in this series of cases is not unique. Of seventy-seven previously reported cases in the literature, sixty-seven were males and ten were females. This corresponds roughly to the incidence of "sacro-iliac" and "lumbosacral" strain with sciatica in males and females and suggests strongly that trauma is a major etiological factor.

Trauma

In thirty-one (77.5 per cent.) of the cases, there was elicited a history of trauma which the patient felt was a causative factor. In twenty-one instances the disability followed *immediately* after the trauma and in ten there was a latent period before the onset of symptoms.

The type of trauma was extremely varied; the most common was lifting a heavy weight. Falls from a height and twisting strains were much less frequent. These facts suggest that abnormal pressure on a disc can produce a sudden rupture of the annulus fibrosus with immediate posterior prolapse of sufficent disc tissue to produce pressure on the cauda equina. It is possible that in other cases there had been in the past some unremembered trauma which produced a slight tear or weakening of the annulus fibrosus. The ordinary stresses of weight-bearing over a period of time were then sufficient to produce a slowly enlarging herniation or prolapse of disc tissue. In their case reports, Kocher, Middleton and Teacher, Dandy, and Alajouanine and Petit-Dutaillis have all emphasized the element of trauma in the production of the lesion. Experimental evidence is scanty. Ribbert was able to produce Virchow's tumor (ecchondrosis physaliphora) in rabbits by puncturing the intervertebral disc. Schmorl stated that Roux was able to rupture intervertebral discs in excised spines by compressing them hydraulically. Petter found that the average expansile force of each intervertebral disc was thirty and two-tenths pounds per square inch.

The author of this paper has tested the effect of pressure on discs excised at autopsy in the following manner. A portion of the lumbar spine, consisting of two vertebrae, was excised by passing a knife through the intervertebral disc above and below and removing the muscles by sharp dissection. The cartilage plates were left intact on either end. The vertebrae were then placed in a vise and pressure was gradually applied to the vertebrae and the intact disc between them by tightening the jaws of the vise on the cartilage plates on either end. As the pressure was increased, the height of the disc decreased and it bulged symmetrically at its periphery. When the pressure was released, the disc resumed its normal shape. This could be repeated *ad libitum*, demonstrating the usual elastic behavior and function of the disc. If the pressure was increased beyond a certain point, there ensued a sudden rupture of the disc at its periphery with escape of a portion of the disc tissue (nuclear material) through the longitudinal ligament. The disc then lost its elasticity and failed to return to its normal shape when the pressure was released.

This rupture of the annulus fibrosus seemed to occur at any point in its periphery. If the annulus fibrosus was punctured with a needle or with the tip of a scalpel, the rupture invariably occurred at that point. It would seem that the disc is composed of an incompressible semifluid center (nucleus pulposus) contained in a highly elastic envelope which is the annulus fibrosus. If the tensile strength of the annulus fibrosus is exceeded, rupture occurs and the whole unit loses its function. A rich field for investigation is here opened. Further work is necessary to determine the pressure required to produce disc rupture, the usual sites of rupture, etc.

Pease has reported twelve instances of injury to intervertebral discs, as shown by narrowing of the intervertebral space and sclerosis of vertebral bodies, following lumbar puncture, due presumably to trauma which occurred because the needle was introduced too far. In none of his cases was there evidence of root or spinal-cord pressure.

Duration of Symptoms

The duration of symptoms from onset to operation varied widely. The shortest period was six weeks; the longest, twenty-two years; and the average, thirty-four months. Twenty-four of the patients (60 per cent.) were suffering from the original disabling attack when operated upon. Sixteen patients (40 per cent.) had had remissions and recurrences of symptoms. *A priori*, one would suppose that a herniation of the intervertebral-disc tissue, sufficient to produce nerve-root pressure, would remain as a constant etiological factor until removed at operation and that it would be impossible for a patient to recover and remain symptom-free under conservative treatment. However, in many of these cases the patients had recurring attacks with remissions. The symptoms usually became more disabling with each attack. It is interesting to speculate as to what happens in these cases with recurrent symptoms. Does the prolapsed tissue shrink in size or return to normal position with rest, etc., or does the nerve root involved alter its position by slipping to one side? We certainly have no definite knowledge concerning these matters. Other authors, particularly Elsberg and Stookey, have noted that there may be remissions and relapses in the symptoms.

Analysis of Symptoms

Pain was the usual chief complaint and was the major presenting symptom in every case. The painful areas in order of frequency were: (1) posterior and lateral thigh, 100 per cent.; (2) posterolateral calf, 90 per cent.; (3) lumbosacral region, 70 per cent.; (4) gluteal and sacro-iliac regions, 65 per cent.; (5) lateral border of foot, 5 per cent. Other areas, such as the sole of the foot, the great toe, etc., were complained of in single instances.

The pain in the lumbosacral region is perhaps best explained by the local irritation of the injured disc. According to Schmorl, the disc itself has no nerve supply, but the posterior spinal ligament has a sensory supply

and thus strain or pressure on it from the prolapsed disc would presumably be painful.

The pain in the thigh and the leg was of the type commonly referred to as "sciatic". It was usually described as a deep-seated burning or shooting pain, often excruciating in intensity. The pain varied greatly in intensity and was often aggravated by coughing, sneezing, and change in position. The position of least discomfort varied greatly. Bed rest usually brought some relief, but some patients were more comfortable standing or sitting. At operation the ruptured disc fragment was found to press on only *one* root of the cauda equina in over half of the cases. Hampton and Robinson have demonstrated that, if the rupture is in the disc between the fourth and fifth lumbar vertebrae, the root of the fifth lumbar is always involved, whereas, if the rupture is in the lumbosacral disc, the root of the first sacral is the first one pressed upon. The effect of pressure on only one of the roots which go to make up the lumbosacral plexus can thus be demonstrated. In no instance of pressure on one root were there objective sensory changes present. This serves to corroborate Foerster's observation that section of a single nerve root produced little or no sensory change because of the marked overlap in the sensory supply of the skin.

The areas of referred pain were identical, no matter whether the fifth lumbar or the first sacral roots were involved. One might suppose that pain due to irritation of a nerve root would be referred to the peripheral dermatome supplied by that root. This is not true, in so far as we are able to determine. Every patient complained of pain in the posterior thigh (second sacral dermatome). A number of patients with pain in the lateral calf (fifth lumbar dermatome) were found at operation to have a lesion at the lumbosacral disc below the point of exit of the root of the fifth lumbar which was obviously not impinged upon. A careful study of these cases has convinced the author that the referred pain has no obvious relationship to the sensory dermatomes and that the location of the lesion cannot be inferred from the distribution of the areas of referred pain.

In thirty-four instances the referred pain was strictly unilateral. In six there was radiation of pain down both legs.

Although the presenting symptom in each case was pain, a certain number of patients complained of numbness, muscle weakness, cramps in the calves of the legs, and urinary and faecal incontinence. These will be discussed more fully.

Previous Treatment

These patients, almost without exception, had had prolonged orthopaedic treatment of one type or another. Bed rest, heat, adhesive strapping, belts, corsets, back braces had all been used many times, often with partial or with complete temporary relief.

One patient had had an ether manipulation to reduce a "sacro-iliac subluxation". The result of the manipulation was a complete paraplegia,

due to pressure on the cauda equina from a large rupture of an intervertebral disc. Two other cases of paraplegia following ether manipulation are known to the author, but are not included in this series. This seems to indicate that *manipulations which place severe strain on the lumbar spine are hazardous* and should be abandoned.

One patient in this series had had a sacro-iliac fusion, and two patients had had division of the iliotibial band (Ober fasciotomy) for the relief of low-back "sacro-iliac" strain. The sacro-iliac fusion gave no relief from symptoms. One of the patients upon whom a fasciotomy was done was completely relieved for one year; the other patient was relieved for two months. Both patients then had very disabling recurrences of symptoms and the correct diagnosis was finally made.

Signs

The position in which the lumbar spine was held varied somewhat. In twenty-six cases there was a *list* of the lumbar spine (sciatic scoliosis). The list was away from the site of the lesion (contralateral) in thirteen cases, toward it (homolateral) in eleven cases, and in one case the lumbar spine showed a fixed list, whereas the lesion was in the midline. There was one case of alternating scoliosis in which the list shifted from one side to the other on several occasions.

In twenty-seven cases there was present a lumbar *kyphos* in the region of the spinous processes of the third, fourth, and fifth lumbar vertebrae. This was a fixed deformity in most cases and could not be altered by active or passive attempts to hyperextend the spine. The kyphos represented fixation by muscle spasm and disappeared postoperatively in every case save one after the nerve-root pressure was relieved. In that one case a spine fusion had been done, thus producing a permanent fixed deformity.

In every case in which the record contains specific data *back motions* have been restricted markedly. In some instances all motion of the lumbar spine was abolished both in the standing and in the lying positions. In others, motion was more free in the sitting or in the lying position than in the standing position.

In thirty-six cases in which the straight-leg raising test was made, motion was restricted. It was always more restricted on the side of greater pain. In eleven cases the unaffected side showed no restriction in motion.

Tenderness to pressure was present in the midline at the level of the lesion in fifteen cases, over the posterior sacro-iliac ligaments in fourteen cases, and at the sacrosciatic notch in ten cases. In several instances there were no data as to points of tenderness.

Reflexes

The knee jerks were normal in every instance. The ankle jerk was absent bilaterally in six cases, unilaterally in fourteen cases, normal in nineteen cases, and not stated in one,—*i. e.*, 50 per cent. of the cases showed absent ankle jerk. Those cases in which the ankle jerk was un-

affected were in general milder and of shorter duration than those in which it was absent. The Babinski response was either plantar or absent in all cases but one in which it was equivocal. There was an unsustained ankle clonus in one case.

In three cases there was urinary and faecal incontinence amounting to complete loss of sphincter control. In two cases there was dribbling of urine and in one instance, other than the three cases of paraplegia, loss of sexual potency was noted.

Atrophy with some degree of muscle weakness was noted in eight cases. In three of these the weakness was generalized and involved both legs. In one instance one foot was essentially flail. In one case the gastrocnemius was the only muscle involved.

Two patients showed fibrillary twitching and cramps of the calf muscles.

Sensory Changes

Sensory changes were present in seventeen cases. In three of them there was saddle anaesthesia. The others showed hypaesthesia or anaesthesia of varying extent. The involved areas were similar to the areas of referred pain,—*i. e.*, posterior thigh, lateral calf, lateral border of the foot.

Roentgenographic Examination

The usual flat films (stereo-anteroposterior and lateral) of the lumbosacral region revealed the changes shown in Table VI.

From this experience it would seem that the usual roentgenographic examination gives no information concerning the location of the lesion in

TABLE VI

Changes in Lumbosacral Region as Demonstrated Roentgenographically

Changes	Group Cases	Group Per Cent.	Total Cases	Total Per Cent.
I. Hypertrophic changes, spur formation, increased density of the vertebral margins:				
A. Local at the site of the lesion	13	32.5		
B. General	3	7.5	16	40.0
C. No changes present	23	57.5		
D. Roentgenograms not available	1	2.5	24	60.0
II. Narrowing of the intervertebral disc:				
A. Very marked	3	7.5		
B. Marked	7	17.5		
C. Slight	5	12.5	15	37.5
D. No narrowing	25	62.5	25	62.5
III. Concave vertebral bodies (expansion of the intervertebral disc)	5	12.5	5	12.5

one-half of the cases. In those instances where the roentgenogram shows narrowing of an intervertebral disc and (or) local hypertrophic changes the information might be considered suggestive. It certainly is not *conclusive* evidence of nerve pressure from a prolapsed disc as the routine roentgenographic examination of the spine reveals such changes in cases with no symptoms whatever.

Lipiodol Examination

Lipiodol examination was carried out in thirty-nine of the forty cases. The results are given in Table VII.

TABLE VII

RESULTS OF LIPIODOL EXAMINATION

	Cases
Total block demonstrated	5
Partial block or filling defect	30
Question of filling defect	1
Negative examination	3
Total	39

Of the thirty-six cases with positive lipiodol findings, the location of the lesion was verified at operation in each instance. In other words, there were no "false positive" results. The three patients in whom lipiodol examination gave negative results were found at operation to have small disc lesions so far lateral in the intervertebral foramen that only one nerve root was involved. They were examined with small amounts of lipiodol and the lesions could not have produced filling defects in the lipiodol column. *Lipiodol examination was 90 per cent. accurate in localization of the level of the lesion in this series.* In twenty-five cases the roentgenologist made a diagnosis of "rupture of the intervertebral disc" from the roentgenographic findings alone.

The technique of lipiodol examination has been reported in detail by Hampton and Robinson. It is important to inject a large enough quantity of lipiodol to fill the lower dural sac, thus permitting examination of the lower two intervertebral discs in the standing position. We now use from four and five-tenths to five cubic centimeters of the iodized oil. Careful fluoroscopic examination is made and "spot films" of any block or filling defect are taken. The anteroposterior or slightly oblique view has usually demonstrated the lesion better than the lateral view.

No untoward results from the use of lipiodol occurred in any of our cases. Arachnoiditis has been reported by other writers. In each case at the time of operation as much lipiodol as possible was removed from the spinal fluid.

In thirteen of the cases postoperative roentgenograms of the lumbar

spine were obtained. The longest period of time after operation was five years; the shortest, five weeks. The results of this examination are discussed later in the end-result study.

Lumbar Puncture

Lumbar puncture was performed in each case. Manometric test revealed evidence of a dynamic block above the level of the needle in four cases (10 per cent.). In the other thirty-six cases the dynamics were normal. The total protein has been above 45 milligrams per 100 cubic centimeters in thirty-five of the cases. The others had total proteins of 27, 33, 35, 40, and 41 milligrams per 100 cubic centimeters respectively.

Until the past year, a total protein below 40 milligrams per 100 cubic centimeters was considered indicative of no pathology in the cauda equina and, therefore, in such cases lipiodol examination was not done. At the present time, if the patient's symptoms and clinical examination are consistent and he is unrelieved by conservative therapy, we do not hesitate to do a lipiodol examination even when the total protein is within normal limits (20 to 40 milligrams per 100 cubic centimeters). The fact that five cases of proved disc lesions have been found, each with spinal-fluid total protein within normal limits, is disturbing. *We now know that a negative lumbar puncture does not rule out rupture of the intervertebral disc.*

In one or two instances the spinal fluid was xanthochromic. The white blood count and the red blood count revealed a very few cells in some instances. There was no case with a significant increase in the cell content of the fluid. The gold-sol and Wassermann tests were negative in each instance. The chloride and sugar content of the spinal fluid was not altered appreciably in any instance.

OPERATIVE TECHNIQUE AND FINDINGS

In this series of cases, with one exception, the operations were performed on the Neurosurgical Service and most of the cases were operated upon by Dr. W. J. Mixter, the Chief of the Neurosurgical Service. The operative technique has been described by Elsberg, Stookey, and Mixter. A laminectomy is done in which the spinous processes and laminae of from two to four vertebrae are removed as seems indicated. If the lesion has been accurately localized and lies on one side, a hemilaminectomy may be done. In those instances where the lesion is small and lies far laterally in the intervertebral foramen, it is usually necessary to remove one articular facet and a portion of the pedicle before the lesion can be demonstrated. After the dura has been thoroughly exposed, it is palpated carefully. Usually the intervertebral-disc lesion can be felt through both layers of the dura, appearing as a small nodule over which the finger rides. If the lesion lies laterally and can be felt without opening the dura, it may be possible to remove it extradurally. It usually was necessary to open the dura in order to gain accurate knowledge as to the position and the size of the lesion, and in most instances it was necessary to remove the lesion trans-

durally by a second vertical incision through the anterior dura after carefully separating and retracting the fibers of the cauda equina. Before the dura is opened, the patient's head is raised slightly, allowing the lipiodol to fall into the sacral cul-de-sac. After the dura has been opened, cotton pledgets are carefully packed in the upper end of the incision and the lipiodol is removed with the suction apparatus. In this way all but a very small portion of the lipiodol is removed, and can no longer be a potential source of arachnoiditis. After the lesion is located, examination of the nerve root or roots impinged upon shows that they are usually flattened and the sheaths are injected, giving objective evidence of the irritation which has occurred from the pressure of the protruding mass. After exposure of the lesion, which appears as a small rounded eminence, usually varying in size from that of a pea to that of a hickory nut, the dura is incised over it. A pair of Allis forceps is introduced and the mass is grasped firmly. It can usually be removed *in toto* without sharp dissection. The mass has an appearance similar to wet, rolled-up blotting paper, usually grayish or pinkish in color. Occasionally it is necessary to sever one or two of its attachments to the intervertebral disc with scissors or scalpel. If a probe is introduced into the spot from which the mass was removed, a hole can usually be demonstrated which runs down into the depths of the intervertebral disc. In several of these cases such a sinus was demonstrated and its connection with the nucleus pulposus was shown by introducing a silver clip into the area; its location was then demonstrated by postoperative anteroposterior and lateral roentgenograms. The defect in the anterior dura is not repaired. The posterior dural incision is sutured with black silk and the operative incision is closed in the usual fashion.

The question of whether a spinal fusion should be performed following the laminectomy is of great importance. On theoretical grounds it would seem that a spinal fusion might help to prevent further posterior displacement of intervertebral-disc tissue and recurrence of symptoms. In one of the cases in which spinal fusion was performed the patient had at the time of operation a fixed kyphoscoliosis. Fusion was rapid and complete and the patient's spine has remained in the deformed position. It would seem, then, that if fusion is performed, it should *not* be done in the presence of altered spinal mechanics such as scoliosis or kyphosis. If the laminectomy has been so extensive as to remove one or more of the articular facets, it would seem advisable to perform a spinal fusion to insure sufficient stability for the spine. This might be done either at the time of the laminectomy or at a second operation. In twelve of the forty cases in this series a spinal fusion was done at the same time as the laminectomy.

The postoperative course in these cases has as a rule been quite uneventful. Occasionally catheterization has been necessary for a few days after operation. In two cases there was a definite increase in the amount of motor weakness, presumably due to operative trauma. The immediate and complete postoperative relief from the sciatic pain is

dramatic and strongly suggests that the etiological factor has been corrected!

HISTOLOGY

The microscopic examination of the excised material reveals that it is normal disc tissue and not "chondroma". There is considerable variation in the histological appearance, depending on which portion of the disc was removed and on the age of the subject. If it is the annular portion, dense fibrous tissue with an occasional cartilage cell predominates. If it is chiefly nucleus pulposus, there is a loose granular reticulum, the spaces of which are filled with mucoid material and with occasional poorly differentiated groups of cells which may be remnants of the notochordal cells or of the fibrocartilaginous cells. In some instances there may be present bits of bone or a small part of the posterior longitudinal ligament.

It is by the careful comparison of this material with sections of normal intervertebral discs that we have reached the conclusion that the terms "chondroma", "enchondroma", etc., are not appropriate. The material is simply misplaced intervertebral-disc tissue.

END-RESULT STUDY

Every one of these cases has been followed long enough after operation to know the immediate result, although not enough time has elapsed in some instances to allow us to ascertain the final result.

Two patients have died at the time of completion of this study (December 1936). One died of uraemia following a complete paraplegia with urinary incontinence, due to the disc lesion which was present preoperatively, and death may be appropriately considered as due to rupture of the intervertebral disc. The second patient died, presumably of pneumonia, well over a year after operation. The disc rupture and operation had no apparent bearing on his death, as he had made almost a complete recovery when last seen.

Relief from pain was striking. Twenty-nine patients were completely relieved from pain; nine had only slight residual discomfort. In only one instance was relief from discomfort and pain not essentially complete, and in this instance there was evidence at operation of other pathology,—*i. e.*, arachnoiditis, sufficient to cause continuing symptoms.

Eight patients had no residual disability and were able to resume all their pre-illness activities. Nine patients were restricted to lighter work than they had had preoperatively, but they were otherwise well. Two patients had disabling motor weakness or paralysis. The remaining patients, operated upon within the past year, have not been allowed to resume full physical activity as yet. There were no instances of muscle weakness or paralysis occurring after operation in these recent cases.

The fate of the involved intervertebral disc is interesting and important. In thirteen cases postoperative roentgenograms have been obtained and compared with the preoperative ones. In four there was definite increased narrowing of the intervertebral space and in one of them there

were present increased local hypertrophic changes. This finding was not unexpected, for the disc must have been weakened by the original rupture of the annulus fibrosus and the operative removal of the prolapsed tissue leaves an unrepaired hiatus in the disc which has been proved in several cases to extend into the region of the nucleus pulposus. What is to prevent further extrusion of disc tissue with recurrence of root pressure? The history of the fatal case suggests that this actually occurred. It seems reasonable to assume that as time elapses more of these cases will show degenerative changes (grinding up) of the affected disc and possibly there may be some with actual recurrence of symptoms. The one therapeutic defense against this event would seem to be the thorough removal of the nuclear material at the time of the operation plus spinal fusion of the affected area.

FIG. 1

Photograph of a portion of a spine removed at autopsy. Pedicles have been cut near the vertebral bodies, thus removing the neural arch and the spinal cord. A posterior prolapse, measuring one centimeter in diameter, is present. It occasioned no symptoms, but it is quite similar to those which do cause nerve-root pressure.

CASE REPORT

The following case abstract illustrates some of the points discussed in the paper. The case is the most recent one of the forty here reported.

V. C. (M. G. H. No. 356804), female, aged twenty-five, is an unmarried clerk. Her family history and past history are irrelevant. The patient was first seen in the emergency ward of the Massachusetts General Hospital on October 10, 1936. Her chief complaint was pain in the left posterior thigh and calf. Three years previously the patient had had a sudden attack of pain in the left sacro-iliac region following vigorous exercises to reduce her weight. Osteopathic manipulation and rest in bed had relieved the symp-

toms. During the previous three years she had had three similar attacks, each beginning with some minor twist or strain of the low back. Each time the symptoms had been relieved by osteopathic manipulation, adhesive strapping, and rest in bed. In the interval between attacks she had felt perfectly well.

The last attack began in similar fashion two weeks previous to admission, but was much more severe and she had obtained no relief even from rest in bed. There was mild discomfort across the lumbosacral region and over the left sacro-iliac region. Intense pain radiated down the left posterior thigh and posterior lateral calf to the external malleolus. Coughing, sneezing, and twisting motions caused exacerbation of the pain.

On examination the patient stood with most of her weight borne on the right leg. The lumbar spine was held rigidly and the normal lordosis was obliterated. There was a fixed list to the left (homolateral scoliosis). In the standing position, all motions of the lumbar spine were markedly restricted by pain and muscle spasm. In the sitting position, motions were a little more free but were still markedly restricted. There was tenderness in the midline over the spinous processes of the fourth and fifth lumbar vertebrae. There was no tenderness elsewhere. Straight-leg raising was limited by hamstring spasm to 40 degrees on the left and to 60 degrees on the right.

There were no sensory changes. All reflexes, including the ankle jerks, were equal and active.

Lumbar puncture, done at the interspace of the fourth and fifth lumbar vertebrae, showed no alteration in dynamics. The total protein was 46 milligrams per 100 cubic centimeters.

Five cubic centimeters of lipiodol was injected into the subarachnoid space. On fluoroscopy, a characteristic filling defect was found at the level of the disc between the fourth and fifth lumbar vertebrae on the left side, which was interpreted as a ruptured disc.

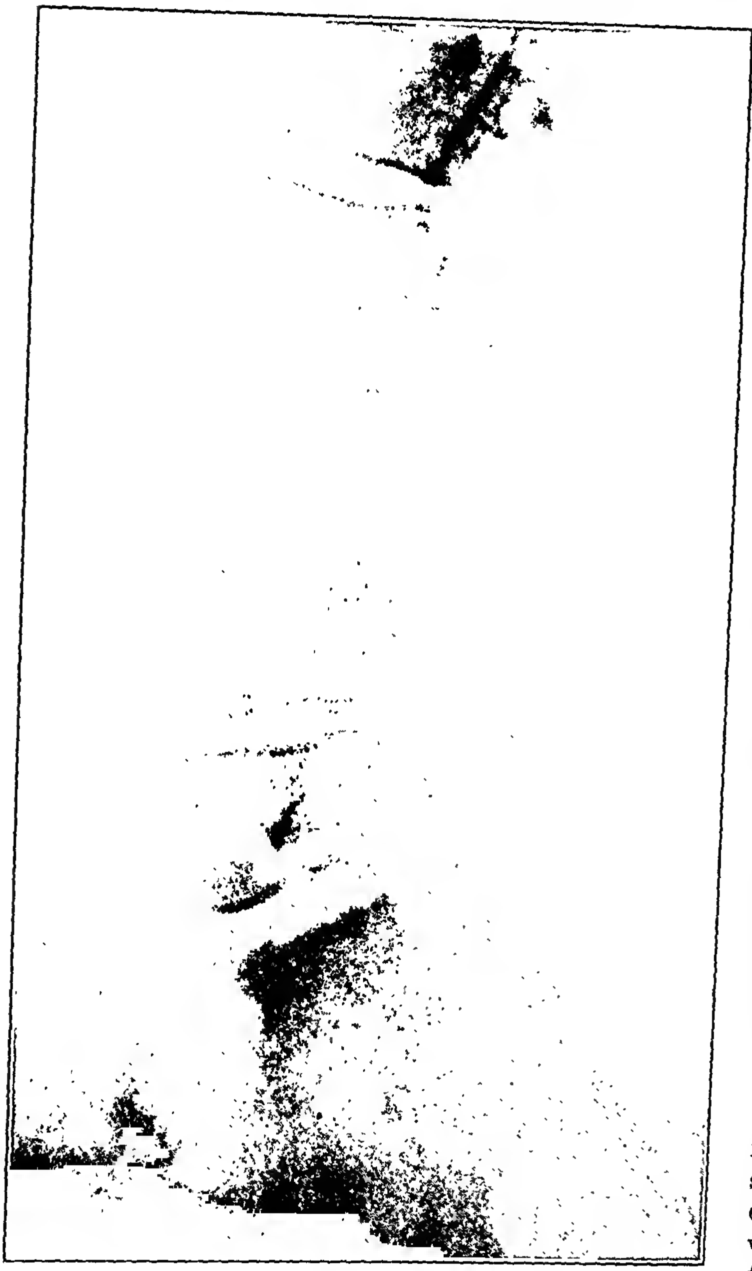

Fig. 2

Lateral view of the lumbar spine of patient V. C. Note the slight narrowing of the interspace of the fourth and fifth lumbar vertebrae, and the slight spur formation on the anterior margins of the fourth and fifth vertebral bodies.

At operation on October 17, 1936, the dura was exposed through a left hemilaminectomy. The laminae of the third, fourth, and fifth lumbar vertebrae were removed, together with the articular facet between the fourth and fifth vertebrae. On palpation of the dura, a mass about one centimeter in diameter could be felt, arising anterior and to the left of the dura at the level of the disc between the fourth and fifth lumbar vertebrae. It encroached upon but did not completely occlude the subarachnoid space. When the dura was opened, the left fifth lumbar root was seen to ride over the mass. The root showed evidence of irritation, as it was covered with a fine network of injected blood vessels. The dura and cauda equina were retracted toward the midline, exposing the mass extradurally. On incision of the posterior longitudinal ligament, a ragged detached fragment of the intervertebral-disc tissue was easily extracted. It measured about one by one by five-tenths of a centimeter and resembled in the gross a fragment of fibrocartilage. All the pressure on the involved root was relieved by this manoeuver. The lipiodol was removed by suction. The dura was closed with silk. A Hibbs type of fusion was then done on the right side from the third lumbar vertebra to the sacrum inclusive. The wound was closed with silk, and the patient was placed in plaster shells which had been made before the operation.

Fig. 3

Anteroposterior "spot film" of the low lumbar spine of patient V. C. after injection of lipiodol. Note the filling defect on the left side at the level of the disc between the fourth and fifth lumbar vertebrae. This defect remained constant on repeated examinations. The rupture was found at operation at exactly this location, but was not quite as large as the x-ray seemed to indicate.

Postoperative convalescence was uneventful. The patient had no sciatic pain after the operation. She was discharged from the Hospital on November 10, 1936, free from all symptoms. The final result cannot be determined as yet as insufficient time has elapsed since the operation.

The histological section of the removed tissue was reported to be from a normal intervertebral disc.

SUMMARY AND CONCLUSIONS

A review of the literature reveals that much is known of the normal anatomy and physiology of the intervertebral disc and that, chiefly due to Schmorl's work, the pathological changes which may occur are fairly well elucidated. The entity of posterior prolapse into the spinal canal is of great clinical significance, as it may cause disability and even death from pressure on the cord or on the cauda equina. The lesion known as "chondroma" or "ecchondrosis" of the intervertebral disc is apparently the same as the posterior prolapses.

The cases in which the lesion is in the low lumbar spine may show symptoms and signs indistinguishable from those of sacro-iliac or lumbosacral strain and so are seen primarily by orthopaedic surgeons.

Unless the specialists in this field are aware of the entity and take the proper steps to arrive at the correct diagnosis, useless orthopaedic treatment will be instituted. A careful neurological examination, in addition to the orthopaedic examination, is indicated in every case of "low-back strain". If the symptoms remain intractible after adequate conservative treatment, lumbar puncture should be performed and the total protein content of the spinal fluid should be determined. If it is over 50 milligrams per 100 cubic centimeters, the evidence is in favor of an intraspinal lesion rather than mechanical joint or ligamentous strain, and, therefore, sacro-iliac or lumbosacral fusion is contra-indicated until cord or root pressure is ruled out by careful lipiodol roentgenographic examination. Even if the total protein is within so called normal limits, there may be present a ruptured disc which is responsible for the patient's symptoms.

Forty cases of proved rupture of the intervertebral disc into the lumbar spinal canal with involvement of one or more roots of the cauda equina by direct pressure have been reported in this paper. Twelve were in the lumbosacral disc, twenty-six in the disc between the fourth and fifth lumbar vertebrae, one between the second and third lumbar, and one between the third and fourth lumbar.

There were thirty-five males and five females. The average age was thirty-seven years.

A history of trauma was present in 77.5 per cent. of the cases.

Pain was the major presenting symptom. Its character was that of the familiar "sciatica", always radiating down the posterior thigh and usually the posterolateral calf.

Orthopaedic examination revealed the classical signs of low-back strain,—muscle spasm, list, limitation of motion, limitation of straight-leg raising, tender areas, etc. Fixed lumbar kyphosis or an abnormally flat back was present in over half of the cases.

Neurological examination revealed definite peripheral sensory changes in seventeen cases. There was an absent ankle jerk in 50 per cent. of the cases. Muscle weakness, paralysis, cramps, and loss of urinary and rectal control were less frequent, but they occurred.

Lumbar puncture revealed an elevated total protein in all but five cases. The average was 60 to 100 milligrams per 100 cubic centimeters.

Roentgenograms showed local hypertrophic changes or disc narrowing in less than half the cases.

Lipiodol examination localized the lesion in thirty-six of the forty cases.

The end-result study showed one death due to the lesion (paraplegia). There was essentially complete relief from pain in all cases but one. In that one the continued pain seems to be due to other pathology.

Sufficient time has not elapsed to permit determination of the amount of permanent disability following the operative removal of a ruptured disc. Our experience indicates that the back is stronger if fusion is combined with the laminectomy.

There seems to be no doubt that a clinical entity with a proved

pathological etiology is being removed from the vague classification of lumbosacral and sacro-iliac strains. It is not excessively rare and should be thought of in every case of back strain and "sciatica".

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LESIONS OF THE LUMBOSACRAL SPINE *

Part I. Acute Traumatic Destruction of the Lumbosacral Intervertebral Disc **

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The material herein contained is the result of a study of 1,000 cases of chronic or recurring pain in the lower part of the back, which, in the majority of cases, radiated down one extremity and occasionally down both extremities.

The average patient in this series who had suffered pain for a considerable length of time had lost faith in all forms of therapy. The patients frequently gave histories of having had their tonsils and teeth, and occasionally their appendices, removed. In the case of a male, it was generally found that the prostate had been massaged on numerous occasions, and, in the case of a female, one or more pelvic operations had usually been performed. In addition, these patients had been treated by chiropractors and physical culturists, without any appreciable or lasting relief from symptoms.

The knowledge gained from the extensive study of the intervertebral disc in recent years by such men as Schmorl, Schanz, Beadle, Lyon, Haumann, Calvé and Galland, and Compere and Keyes, if applied practically to the clinical case, will eliminate many of the useless forms of therapy employed today. It is true that infection and congestion play a part and in many cases undoubtedly bring the symptoms into prominence; however, this is true of any mechanically altered articulation which is under strain. The author is convinced that such factors are secondary in nature and that the primary pathological change is a mechanically altered lumbosacral articulation, resulting in most cases from changes in the intervertebral disc.

The disc furnishes the intervertebral support and keeps one vertebral body separated from its adjacent segments. It also maintains the articular surfaces of the facets in their proper relationship with each other. With the destruction of the disc, the vertebral body above settles and approximates the segment below. In so doing, this body carries with it its inferior articular facets, causing a partial subluxation of the joints formed by its inferior facets and the superior facets of the vertebral segment below. This, in turn, causes a constriction of the foramina through which the segmental nerve roots traverse. Any mechanically altered

* Material used in this study was presented in the Scientific Exhibit at the Annual Meeting of the American Academy of Orthopaedic Surgeons in St. Louis, Missouri, in January 1936. Also, part of this material, with clinical cases, was presented at the Meeting of the Clinical Orthopedic Society in Dallas, Texas, October 30, 1936.

** Part II, dealing with chronic traumatic destruction of the lumbosacral intervertebral disc, will be published in the July issue of *The Journal.*

joint in which the relationship of the normal weight-bearing articulating surface has been disturbed will, after a period of time, show degenerative arthritic changes. Lange, in his recent monograph, has called attention to the fact that the microscopic findings in these mechanically altered facet articulations are the same as those found in hypertrophic arthritis of the hip. Haumann states that "without pathological changes in the disc one cannot have spondylitis".

The component parts of the intervertebral disc are: the nucleus pulposus, the annulus fibrosus, and the two cartilaginous plates.

It has been shown that it is the nucleus pulposus, rather than the annulus fibrosus, that furnishes the intervertebral support. With a loss of function of the former, the latter undergoes an atrophic degenerative change. Hildebrandt and Lyon have described these degenerative changes. The function of the annulus fibrosus is that of a limiting structure for the nucleus pulposus, as is also that of the cartilaginous discs. Acute traumatic compression may so increase the pressure within the nucleus pulposus that either a herniation of the cartilaginous plates, as shown by Schmorl, or a rupture of the annulus fibrosus may take place. In either event the intervertebral space becomes narrower and a partial subluxation of the joints formed by the facets results. Due to the physical properties of the intervertebral disc, a sudden rupture of the nucleus pulposus is more likely to occur in young adult life than it is in a later period of life, after chronic traumatic degenerative changes have taken place and the viscous content of the nucleus pulposus has been replaced by fibrous tissue.

Chronic traumatic compression over a prolonged period of time results in degenerative changes in the intervertebral disc. There seems to be some difference of opinion as to where these changes first take place. Keyes and Compere state that "in discs unaffected by pathological processes, the nucleus pulposus retains its semigelatinous consistency even beyond the fifth or sixth decade". This leads one to believe that the fibrous degenerative change in the nucleus pulposus, so frequently seen in the third and fourth decades of life, is not a natural change, but one due to a pathological process. That such a process is the result of chronic trauma and probably occurs first in the limiting annulus fibrosus is suggested by the fact that a narrowing of the intervertebral joint spaces occurs during the third decade of life on the concave side of all spinal curvatures whether they be scoliosis, lordosis, or kyphosis. In such a spine the weight is not supported by the nucleus pulposus as it should be, but is transmitted from one vertebra to another through that portion of the annulus fibrosus which bounds the concavity of the curve. Since this is not a supportive structure, a traumatic degenerative change takes place as the individual grows to adult life and thereby increases the load. These degenerative changes, as suggested by Schmorl, open avenues of escape for the gelatinous nuclear content, and a gradual narrowing of the joint spaces results. All curvatures eventually may result in symptoms,

due to the mechanical alteration of the joints formed by the facets. However, symptoms resulting from a lordosis are likely to be more severe, in that a settling of the discs posteriorly not only causes a subluxation of the facets but also a constriction of the foramina.

The intervertebral disc between the fifth lumbar and the first sacral vertebrae is subject to more trauma, both acute and chronic, than any other intervertebral disc. This is due to the facts that it carries a heavier load and that the lordosis is greater at this site than at any other part of the spine. This disc is found by x-ray to be destroyed more frequently than any other. The next most commonly destroyed is that between the fourth and fifth lumbar vertebrae.

FIG. 1

The lumbosacral intervertebral disc is destroyed more frequently than any other, the next most common being that between the fourth and fifth lumbar segments. The latter causes segmental symptoms throughout the distribution of the fourth lumbar nerve.

The writer has never seen a herniation of the nucleus pulposus through the cartilaginous plates into the bony substance of the vertebrae, as described by Schmorl, at the lumbosacral articulation. This is undoubtedly due to the fact that the weight, instead of being transmitted through the nucleus pulposus to the first sacral segment, is received to a large extent by the posterior fibers of the annulus fibrosus. The author is convinced that the nuclear content escapes through the damaged posterior fibers of the annulus fibrosus, as shown in Figure 2.

The clinical symptoms emanating from such a lesion are of two sources. The first to appear are those resulting from the subluxation of the facets. This may manifest itself in the form of a chronic low-back pain with periods of increased severity following unusual movement at this site, or symptoms may appear in the form of attacks following unusual strain and commonly spoken of as "lumbago". The other symptoms make their appearance later, after degenerative changes of the disc have progressed sufficiently to cause a constriction of the foramina great enough to result in an irritation of that portion of the nerve which Sicard has called "the funic-

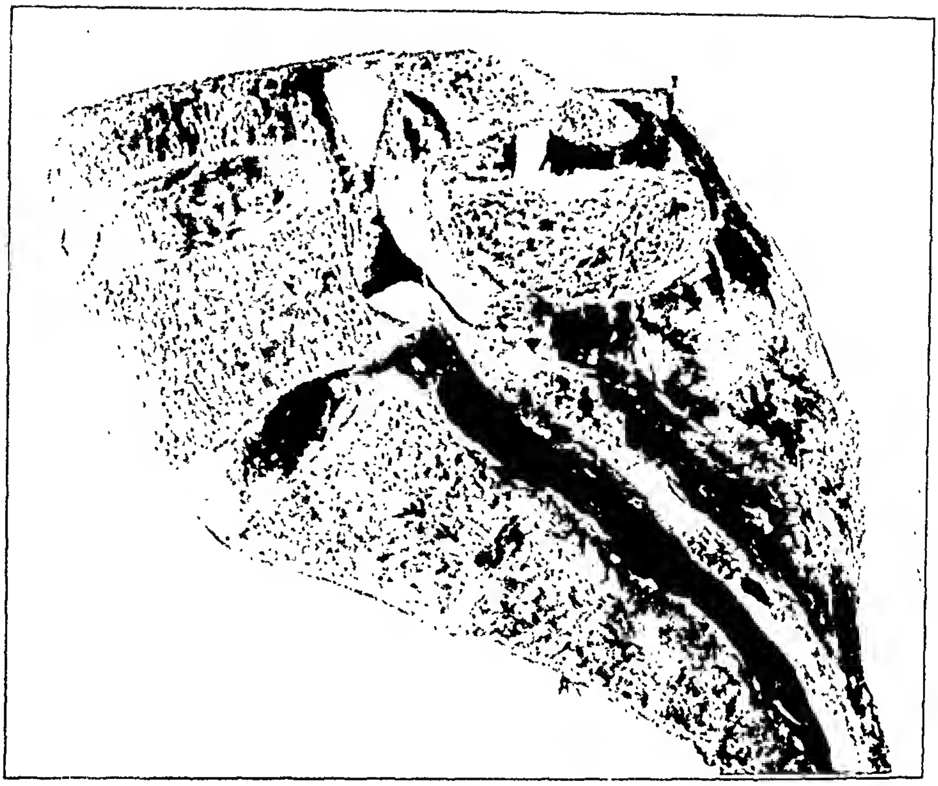

Fig. 2

Anatomical specimen, showing posterior prolapse of the nucleus pulposus into the neural canal.

ulus". At this stage, the syndrome presented is that which is so frequently diagnosed as "sciatica", but which in truth is a neuralgia or a neuritis of the fifth lumbar nerve, depending on the degree of nerve involvement.

Hypertrophic degenerative changes soon appear around the margins of the facets. These add to the possibility of nerve-root involvement. Lipping also appears around the inferior margin of the fifth lumbar vertebra and is undoubtedly due to abnormal stress between two bony surfaces which normally are protected from one another by the resilient supportive nucleus pulposus.

The author is unable to agree with those who say that an escape of the nuclear contents elsewhere in the spine does not cause clinical symptoms. During the past year he has seen eight such cases in which the nucleus involved was located within the thoracic spine. Most of these patients had been treated for gall-bladder and stomach disorders. A topographical neurological examination usually revealed a hyperalgesia over the sensory distribution of the nerve involved and there was tenderness to thumping over the corresponding vertebral segment. The roentgenograms showed a localized hypertrophic arthritis at this site with a narrowing of the intervertebral space. The usual diagnosis made in such a case is hypertrophic arthritis without regard for the destruction of the supportive nucleus pulposus which is probably the primary pathological change, the hypertrophic arthritis being the result of abnormal stress which followed destruction of the disc.

A thorough knowledge of the mechanics of the lumbosacral spine is important in the diagnosis and in the treatment of lesions at this site. In this connection it is well to call attention to the fact that the entire weight of the torso is transmitted to the lumbosacral disc as a forward sheering force. Anterior displacement is prevented by the first sacral facets which normally are located anterolaterally to the inferior fifth lumbar facets.

Flexion of the spine causes a compressive force on the anterior margins of the intervertebral discs and an increase in diameter of their corresponding foramina. Extension of the spine causes a compressive force on the posterior margins of the intervertebral discs and a constriction of their corresponding foramina. This undoubtedly accounts for the pain in the lower back and leg occasionally observed in patients convalescing from a compression fracture of the spine. Lateral flexion likewise causes a compression of the lateral margin of the discs with a partial closure of the foramina on the same side and a widening of those on the opposite side.

The plane of the articular surfaces of the first sacral facets is frequently down and backward. Since the inferior fifth lumbar facets are locked over the first sacral facets, a settling of the fifth lumbar segment takes place in a downward and backward plane, producing a posterior displacement of the fifth lumbar vertebral body in its relationship to the first sacral segment. The greater the lumbosacral angle, the more marked is the posterior tilt of the first sacral facets and thus the greater the posterior displacement of the fifth lumbar vertebra.

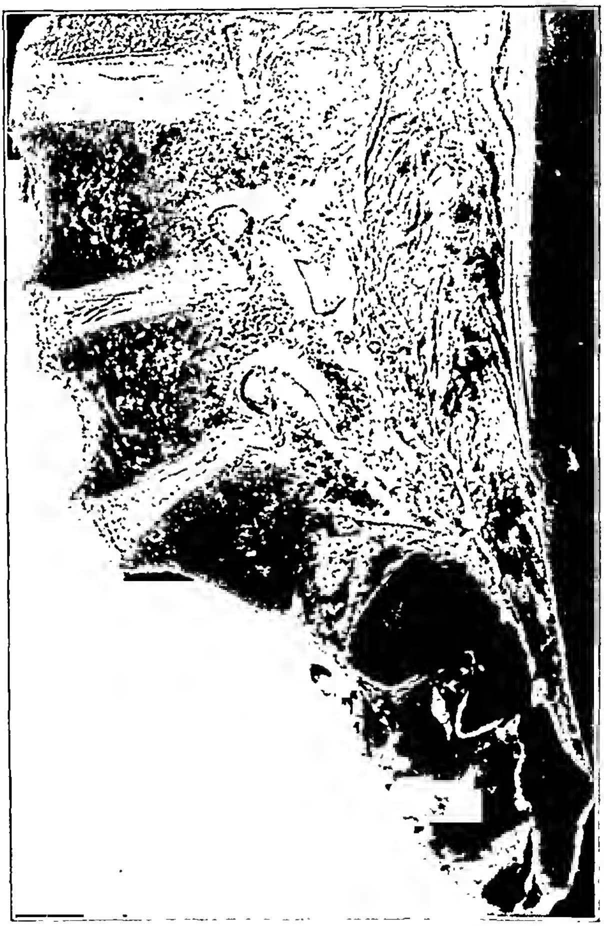

Fig. 3

Anatomical specimen, showing subluxation of the lumbosacral facets and impingement of the fifth lumbar nerve by the first sacral facet. (*Courtesy of Dr. Yglesias.*)

FIG. 4

As the disc settles, the fifth lumbar vertebra is pulled backward if the articular surfaces of the first sacral facets are in a downward and backward plane.

This mechanical alteration has recently been described as a primary pathological entity, but its occurrence is only secondary to a thinning of the lumbosacral intervertebral disc. Contrary to recent reports by Willis and Reynolds that such a displacement is an optical illusion, the author believes it to be an actual displacement which follows natural laws. Due to the absence of soft tissues, the writer considers museum material worthless in proving the point.

The extensor muscles of the human spine are overdeveloped, due to the continued effort involved in maintaining the erect posture against gravity. This overdevelopment has been accomplished at the expense of the antagonistic flexor muscles. The imbalance between the two groups of muscles has resulted in a deformity of the low spine in the form of a lumbosacral lordosis. This is undoubtedly a pathological deformity, but, due to its universal appearance, we must consider it the normal as determined by the law of averages.

The principal muscles of extension are the sacrospinalis group. A contraction of this group, when a person is in a flexed position with gravity counteracting the muscle pull, results in a vertical compression of the lumbar vertebrae and their intervertebral discs. The compressive force increases in proportion to the load lifted. As the person approaches the erect posture, the lumbosacral spine assumes a position of extension and the contraction of the sacrospinalis then compares favorably to the action of a bow string. The vertical compressive force shifts from the anterior margins and nuclei pulposi to the posterior margins of the intervertebral discs. The significance of these mechanical principles of the lumbosacral articulation will be emphasized under the treatment of the various lesions of this site.

Table I gives the pathological lesions of the lumbosacral spine and their frequency of occurrence as determined by clinical and roentgenographic studies.

TABLE I

Frequency of Occurrence of Pathological Lesions of the Lumbosacral Spine in 400 Cases

Lesion	Cases	Per Cent.
Destruction of the lumbosacral intervertebral disc	285	71.25
Lumbarization of the first sacral segment	35	8.75
Imperfect fusion of the sacral lateral masses	31	7.75
Sacralization of the fifth lumbar vertebra	28	7.00
Spondylolisthesis	13	3.25
Facet fragmentation and anomalies	8	2.00
Total	400	100.00

The material in this report has been collected over a period of four years and is a study of 1,000 cases. However, since the significance of an imperfect fusion of the sacral lateral masses was not appreciated until after the first 600 cases had been collected, the frequency of occurrence of the various lesions has been determined from only the last 400 cases.

The omission of the disorders of the sacro-iliac synchondrosis as a primary etiological factor in this classification will undoubtedly be questioned by many; however, the author has found neither anatomical, roentgenographic, nor clinical evidence to support such a hypothesis. A secondary sacro-iliac arthritis is a common finding in those cases showing an imperfect fusion of the sacral lateral masses.

The study of the routine anteroposterior and lateral roentgenograms of the lumbosacral spine rarely reveals the cause of symptoms in this group of patients. Recent experience has taught us that we can no longer focus our attention on the vertebral body alone for evidence of destructive lesions, of compression fractures, and of hypertrophic arthritis. The pathological change is usually found to involve the intervertebral disc and the articular facets. This demands the employment of a more careful technique in posing the patient, in order that the site in question may not be hidden by superimposed bony structures. A routine technique which has been used with success in these cases has recently been described by Dr. Wigby and the author.

It is impossible in all cases to determine whether or not the destruction of the intervertebral disc has resulted from an acute or from a chronic injury. For this reason it is necessary to combine the two groups in reporting their occurrence. However, the clinical history and the roentgenographic findings vary to such an extent in individuals that the

writer is convinced that we are dealing with two groups of patients and for this reason they will be discussed separately. A tuberculous destruction of the lumbosacral disc occurred four times in this series and these cases are included in this classification. They will also be discussed separately.

A careful history obtained from these cases, whether the etiological factor be acute or chronic trauma, will convince the clinician that he is dealing with a disease which is aggravated by position, and thus is probably mechanical in nature.

There have been several men who have called attention to lesions of the lumbosacral articulation in patients suffering with symptoms in the lower part of the back. In this connection, the work of Goldthwait, Danforth and Wilson, Putti, Ayers, Bársony, and Kienböck should be consulted. Ayers was the first to emphasize the significance of a narrowed disc in its relation to symptoms in the lower part of the spine and the extremities.

ACUTE TRAUMATIC DESTRUCTION OF THE LUMBOSACRAL INTERVERTEBRAL DISC

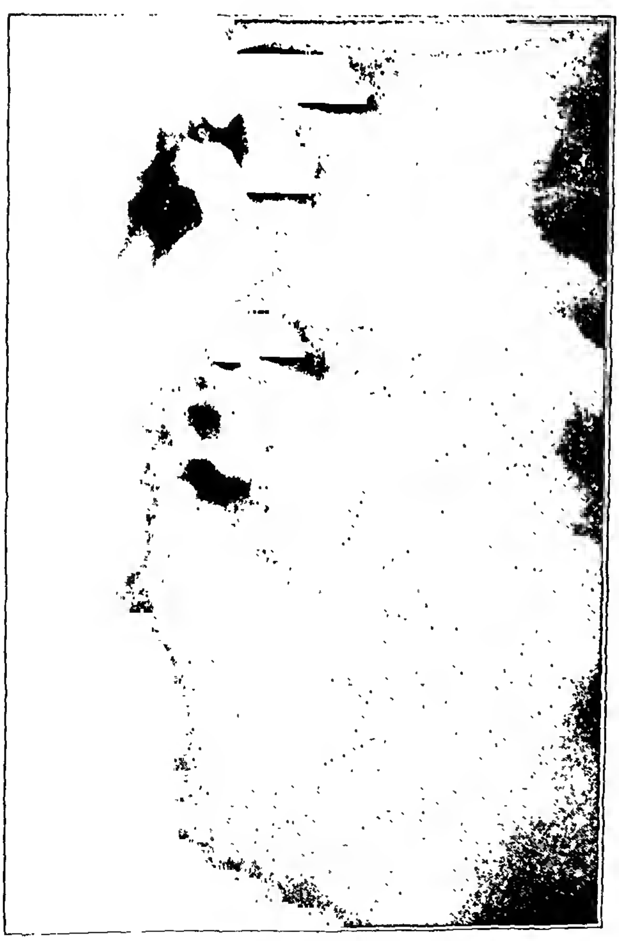

FIG. 5

Acute traumatic destruction of the lumbosacral intervertebral disc. Note the constriction of the lumbosacral foramina.

The roentgenographic appearance of the lesion is shown in Figure 5.

It is the writer's belief that a rupture of the nucleus pulposus not infrequently takes place as a result of a compressive force which occurs during young adult life. Clinical symptoms in this group of patients appear at an earlier age and are usually more severe in character than those appearing at a later period and resulting from a chronic traumatic or postural change. Clinical symptoms and roentgenographic findings suggestive of the acute traumatic lesion are found nearly twice as frequently in men as in women. This can undoubtedly be explained by the more strenuous physical activity on the part of the male.

History

The most common his-

tory obtained is that at some time between the ages of fifteen and twenty-five the patient suffered an injury to the low back. The mechanics is usually compressive in character, such as a fall on the buttocks. Occasionally a definite snapping sensation is experienced at the time of the injury and within a few hours pain develops in the lower part of the back. The patient usually obtains relief from symptoms after a few days, and the injury is considered trivial in nature. Sometime later, varying from a few weeks to several years, while lifting a load or bending backward, the patient again suffers a severe attack of pain in the lower part of the back. Symptoms may come on immediately or they may make their appearance within a few hours. The condition at this time is diagnosed as lumbago, and the patient is treated with some form of fixation, heat, and removal of all possible foci of infection. A gradual relief from symptoms results.

Such attacks may occur repeatedly at irregular intervals and sooner or later the symptoms in the lower part of the back are accompanied by pain radiating down one extremity, and occasionally both extremities, to the lateral aspect of the calf and the ankle. At this stage the usual diagnosis is sciatica, and the patient is rarely ever entirely free from some discomfort, either in the low back or in the legs; this is particularly true during the winter months. A frequent history obtained at this stage is that the patient sleeps on his side with one knee or both knees drawn up and he sits in a slumped position with his feet elevated. During acute attacks, coughing and sneezing severely increase the pain.

Severe exacerbations continue to occur following trauma until about the sixth decade of life, which corresponds to that period in life when degenerative changes are likely to bring about a natural fixation. During this period symptoms frequently disappear entirely.

The most constant physiological principle involved in recurrent attacks is a contraction of the sacrospinalis muscles with the lumbosacral spine extended. In those cases in which lifting is given as the cause, a detailed history will reveal that the injury did not occur until the patient had lifted the load to such a height that the lumbosacral lordosis was restored. Occasionally the lifting of the weight of the torso alone against gravity is sufficient to initiate an attack. Many recurring attacks are brought on by playing golf, most of which can be traced to the use of a wooden club, where a contraction of the sacrospinalis muscles and extension of the spine are necessary in the execution of a drive. Symptoms which appear while the patient is playing a game of tennis are usually first noticed when he is serving the ball. Here again, it is necessary to contract the sacrospinalis muscles and to arch the back.

The following case history is given in brief to illustrate the type of case under consideration:

A male, aged thirty-seven, weight 168 pounds, height seventy-two inches, gave a history of having fallen from a buggy at the age of fifteen, landing on his buttocks. Severe pain in the lower part of the back had followed and he had been forced to remain in bed for a period of about one week. A gradual relief from symptoms had resulted.

He had experienced no further symptoms until the age of twenty-five, when a similar severe attack of pain in the lower part of the back had been initiated by the lifting of a load. The condition had been diagnosed as lumbago, and the patient had been ordered to bed, where he had remained for a period of ten days. Again a gradual relief from symptoms had resulted. Intermittent attacks had occurred on an average of about once a year thereafter until about eighteen months before he was seen by the author, at which time the symptoms became more or less continuous and pain began radiating down the back of the right thigh to the side of the calf and the ankle. He was unable to sleep on his back, but was fairly comfortable when on his side with his knees drawn up. He was more comfortable when sitting on a footstool than he was when sitting in a chair. When sitting in a chair he was more comfortable in a slumped position with his feet elevated.

There is a certain percentage of patients who never experience pain other than in the lower part of the back and gluteal region, although the history and findings are characteristic of the acute traumatic lesion. It is possible that pain along the course of the fifth lumbar nerve appears at a later date; however, the roentgenogram may show a complete settling of the fifth lumbar segment at the time of examination. Such a condition is found more frequently in women than in men, and it is probable that, due to a slight individual variation in the architecture of the lumbosacral facets, the nerve root escapes impingement even though the foramina are partially constricted in these cases.

It is not uncommon in women whose roentgenograms present the findings characteristic of the acute traumatic lesion to obtain a history to the effect that symptoms appeared following the birth of a child. Uterine contractions are frequently accompanied by a severe arching of the lumbosacral spine, due to a powerful contraction of the erector spinae muscles. It is possible that the compressive force on the posterior margin of the lumbosacral intervertebral disc becomes so great at such a time that the annulus fibrosus is ruptured and an escape of the nuclear content follows.

Symptomatology

The symptoms and clinical findings vary widely with the progressive course of the disease as well as with the severity at the time of the examination.

At the time of the original acute injury the patient complains of pain in the lower part of the back. All spinal motions increase its severity. The patient walks with a protective gait and gets up and down with great care, trying to avoid any sudden movement. The sacrospinalis muscles are frequently in spasm, and pressure over them causes pain. There is usually tenderness to pressure over the lumbosacral articulation. All spinal motions are severely limited. A deviation of the spine is an uncommon finding at this stage of the disease. In recurrent attacks symptoms are usually spread to a larger area. A sciatic scoliosis is a common finding. The lumbar lordosis is usually reduced and not infrequently replaced by a mild kyphos at this site. While standing or sitting, the patient takes his weight on his elbows when possible. When designating the areas in which he suffers pain he usually places his hand over the

lumbosacral and upper gluteal regions. Lumbosacral and sciatic-notch tenderness are more prominent findings during the recurrent attacks. There is usually tenderness to pressure over the distribution of the superior gluteal nerve. It is evident at this stage that there are beginning segmental nerve symptoms. Extension of the spine increases the severity of pain, as does also a combination of extension and lateral flexion to the side affected when symptoms are unilateral. Extension of the knee with the hip flexed frequently refers pain to the lumbosacral region.

After segmental symptoms have become more pronounced and the patient complains of pain radiating down the leg, the symptoms and clinical findings vary considerably with the degree of severity,—that is, they depend on whether the patient is suffering an acute severe attack or whether the symptoms are chronic in character. During an acute severe attack, the symptoms differ from those already described in the recurrent attacks of pain in the lower part of the back. The lumbar lordosis is more frequently replaced by a mild kyphosis, and, in extremely severe cases, instead of the usual spinal list the patient presents an attitude in which the trunk is flexed almost to a right angle as shown in Figure 6.

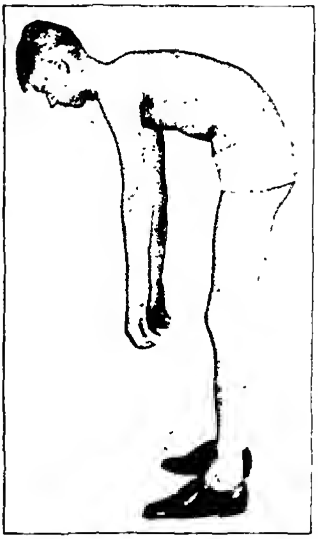

FIG. 6

Flexion attitude assumed in severe cases of impingement of the fifth lumbar nerve. This patient had maintained this attitude for eight months. Complete relief followed facetectomy and fusion.

Such a patient is unable to straighten up and, in attempting to do so, extends the lumbothoracic spine without affecting the kyphosis of the lumbar region. He usually stands with the hip and knee slightly flexed on the side principally affected. Extension of the knee with the hip flexed is limited, due to a protective voluntary contraction of the hamstring muscles. This manipulation produces pain in the lumbosacral region, along the course of the sciatic nerve, and occasionally a tingling sensation on the lateral aspect of the calf and the ankle. A hyperalgesia over the lateral aspect of the calf and the ankle is a common finding. Not infrequently pain is present and there is a sensory change in the form of a hyperalgesia throughout the distribution of one or more of the first three sacral nerves.

In the patient in whom segmental symptoms have become chronic in character there is usually an atrophy of the thigh and the calf. The spinal list is less severe, or it may be entirely lacking. Flexion of the lumbosacral articulation is limited and can be determined by attempting to draw the knees to the axillae. Hamstring limitation is frequently observed and is due usually to a fixed posterior rotation of the pelvis rather than to shortening of the hamstring muscles. The lateral aspect of the

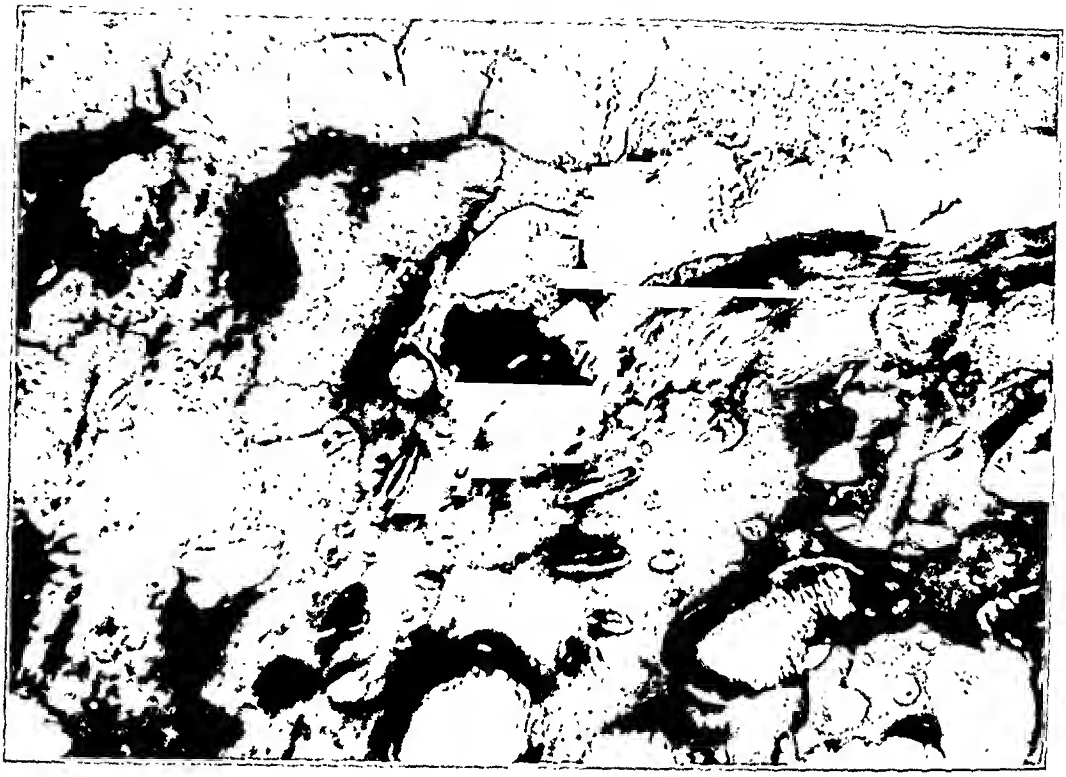

Fig. 7
Section of the first sacral facet removed at operation, showing the sclerotic bone with denuded articular surface (upper border).

calf and the ankle—that is, the sensory distribution of the fifth lumbar nerve—instead of presenting a hyperalgesia, more frequently presents a hypalgesia or anaesthesia, but segmental symptoms throughout the distribution of the sacral nerves are usually less marked. The Achilles-tendon reflex is commonly diminished and occasionally absent. It is evident at this stage, both from the distribution of pain and from the nerve changes, that we are dealing with a lesion involving primarily the fifth lumbar nerve, and that the term "sciatica" is misleading when applied to these cases.

In six cases in this series there was a marked weakness of those muscles in the leg which receive their nerve supply through the fifth lumbar nerve. In four cases the paresis had progressed to such a stage that drop-foot had developed.

Pathology

It is the author's belief that the lesion under consideration is due to a rupture of the posterior fibers of the annulus fibrosus. This permits an escape of the nuclear content. Patients do not die of this disease and for this reason microscopic studies of the disc following the original injury are practically impossible to obtain. Figure 2 shows a herniation of the nucleus pulposus of the lumbosacral intervertebral disc through the posterior fibers of the annulus fibrosus. The nuclear content extends posteriorly into the neural canal. The writer has found three such

specimens in the anatomical laboratory. Badgley recently observed this finding at the post-mortem examination of a patient who had been suffering from the symptoms already described.

Following the escape of the nuclear content, a degenerative change in the disc soon takes place. Compere and Keyes permitted an escape of the nuclear content by incising the anterior fibers of the annulus fibrosus of a dog. Three months later the dog was sacrificed. They found "typical degeneration and fibrosis of the remaining nucleus pulposus and annulus fibrosus". The cartilage plate also showed degeneration, while sclerosis of the bone extended deep into the cancellous portion of the vertebral body. Anteriorly there was beginning osteophyte formation.

A secondary pathological change takes place in the facets as a result of a mechanical alteration which is brought about by the settling of the disc. This is a degenerative arthritic change. Lange states that "the result of the positional changes is that the joints show wear prematurely and an arthrosis deformans develops early". He also states that "the law of functional overburdening has the same significance for the development of the arthrosis deformans in the articulations of the vertebral processes as it has for the development of arthrosis deformans in the joints of the extremities". Figure 7 shows the microscopic degenerative changes of a first sacral facet removed by operation.

The pathological findings, both microscopically and macroscopically, are marginal bony proliferation, sclerosis, and destruction and atrophy of the cartilaginous articular surfaces.

The neuropathological changes present an extremely important phase in the treatment of these patients, yet it is the one concerning which we have the least knowledge.

The funiculus, or that part which traverses the foramen, does not lie within the arachnoid as does the intraspinal portion of the nerve. It is covered by a prolongation of the dura mater around the circumference of which is a rich venous plexus. The nerve at this site is not protected by the cerebrospinal fluid and is, therefore, more liable to external injury than the intraspinal portion of the nerve. The plexus of veins is also subject to irritation from the surrounding foramen, and undoubtedly a traumatic inflammatory congestion results at this site following any mechanical irritation.

Silbermann suggests as a cause of certain cases of sciatica inflammation of the soft meninges, especially of the arachnoid. It is possible that congestion of the venous plexus could result in pathological changes of sufficient severity to extend into and to involve the arachnoid. It is also very probable that the posterior prolapse of the disc into the neural canal, in certain cases, is of such magnitude that it causes a traumatic inflammation of the meninges and not infrequently actual pressure on the sacral-nerve roots. This probably explains the associated sacral symptoms seen in many of these cases in the acute stage. However, the

primary and persistent segmental symptoms are found throughout the distribution of the fifth lumbar nerve and cannot be explained on the basis of a prolapsed lumbosacral disc, due to the fact that the nerve emerges from the neural canal above the posterior prolapse of the intervertebral disc. The author found in a patient recently operated upon that the funicular portion of the nerve showed evidence of scarring and that it had become so adherent to the capsule of the joint formed by the lumbosacral facets that it was necessary to allow a portion of the capsule to remain attached to the nerve after the facets had been removed. Meningeal adhesions were observed by the author at operation in a patient whose roentgenograms showed a narrowing of the lumbosacral intervertebral disc, and who presented clinical findings characteristic of this lesion.

The neural pathology of this lesion still presents an open field for investigation. The recent work of Mixter and Barr and Mixter and Ayer will undoubtedly afford invaluable information in this regard.

Roentgenographic Findings

The principal roentgenographic findings are a narrowing of the lumbosacral disc and a constriction of the lumbosacral foramina. When the articular surfaces of the first sacral facets are in the transverse plane, it is not uncommon to find that, in the process of settling, the fifth lumbar vertebra has been displaced slightly backward in its relation to the first sacral segment. Hypertrophic marginal changes and sclerosis about the facets are frequently observed. Also, osteophyte formation around the inferior margin of the fifth lumbar vertebra and the superior margin of the first sacral vertebra may be apparent in chronic cases.

It is impossible by roentgenographic studies to state definitely in all cases whether the etiological factor concerned in bringing about the destruction of the disc was an acute or a chronic injury. However, in a certain percentage of cases the roentgenogram affords the best means of a differential diagnosis. In cases in which the narrowing of the intervertebral disc is confined to the lumbosacral spine alone, it is very suggestive of an acute traumatic origin. This is particularly true when an exaggerated lumbar lordosis is present. In such a case, if the trauma had been of a chronic character, the narrowing would not have been confined to the lumbosacral disc alone, but would have involved the other intervertebral discs of the lumbar spine. It is also very suggestive in cases where the patients present good posture,—that is, where the lordosis is not of a degree severe enough to bring about chronic degenerative changes, yet the roentgenograms show a marked narrowing of the lumbosacral intervertebral disc.

After chronic degenerative changes of a postural nature have resulted in a generalized narrowing of the posterior portion of the lumbar intervertebral discs it is impossible to say whether the more severe settling of the lumbosacral disc is the result of acute or of chronic trauma.

The narrowing of the lumbosacral disc may include only the posterior half, the anterior portion retaining its normal width; or it may include the entire disc, depending considerably upon the tilt of the sacral table.

Treatment

From a study of the pathological changes which have taken place in these cases it becomes evident that treatment, both conservative and surgical, must be aimed at accomplishing two mechanical principles,—first, a widening of the posterior half of the lumbosacral intervertebral joint space, and thus an opening of the lumbosacral foramina, and, second, an elimination of motion at the lumbosacral articulation.

FIG. 8
Flexion body jacket used in the treatment of patients with acute symptoms. As the patient assumes the erect posture, the sacrum is forced forward and the reduced lumbosacral angle is maintained.

In patients whose roentgenograms show a complete loss of the lumbosacral intervertebral space posteriorly, it is possible, by taking a lateral roentgenogram of the lumbosacral articulation with the patient in a position of acute flexion (accomplished by drawing the knees to the chest), to demonstrate an increase in the width of the posterior portion of the lumbosacral intervertebral space and an increase in the diameter of the corresponding foramina. It is on these findings that all treatment must be based. We must bear in mind that we are dealing with a disease which cannot be corrected from a pathological standpoint. This is due to the fact that, after the intervertebral disc has once been destroyed, a regeneration does not take place. For this reason, our efforts must not stop when relief from the acute attack has been accomplished, but we must go further and attempt to bring about a permanent reduction of the lumbosacral lordosis and thereby approximate the normal diameter of the lumbosacral foramina indefinitely. It is impossible to report statistics on cures, as a cure is never surely permanent until an internal fixation of the lumbosacral region has been accomplished by surgical interference or by natural degenerative changes.

The most gratifying results obtained in relieving the acute symptoms have been accomplished through the application of the principles already mentioned. If a patient presents himself suffering with acute symptoms—whether it is following the original trauma in young adult life, or during a recurrent attack, or during a chronic stage of sciatica—the primary treatment is the same. With the patient standing and with the spine flexed sufficiently to eradicate the lumbosacral lordosis, a plaster-of-Paris

jacket is applied. This position is best obtained by having the patient rest his weight on his elbows, supported by a table the height of which is at about the level of the margin of the lower rib. Posteriorly, the cast extends from the scapulae down to about the third sacral segment. Anteriorly, it extends down to the superior margin of the pubis, but it is trimmed in such a manner that it permits right-angle flexion of the hips without interference from the lower border of the cast, as shown in Figure 8.

When the patient attempts to assume the erect posture after the cast has been applied, he experiences pressure over the buttocks, which forces the sacrum and pelvis forward. The lumbosacral lordosis is reduced and cannot be restored as long as the patient remains in the plaster cast. The eradication of the lumbosacral lordosis causes a partial restoration of the posterior width of the lumbosacral intervertebral space and an increase in the diameter of its corresponding foramina.

Some patients are permitted to continue ambulatory and are instructed to sleep on their backs with the knees propped up. However, most patients are put to bed for a period of ten days or longer, depending on the relief from symptoms. It is important that the patient be maintained in the proper position. The position of choice is on the back with the hips and knees flexed to an angle of about 45 degrees. This position can easily be obtained in the modern hospital bed, as shown in Figure 9.

In order to permit the back of the cast to dry, and to avoid tiresome fixation on the back, the patient is allowed at intervals to turn on either side, but care should always be taken to maintain the flexion of at least one hip and knee. The principal advantage of bed rest for such a period of time is that it permits the traumatic inflammatory reaction about the funicular portion of the fifth lumbar nerve to subside, while fixation in plaster prevents further irritation of the swollen and oedematous structures. After symptoms have subsided to a considerable extent, the patient is permitted to become ambulatory with the cast on. The cast is worn for from one to two weeks.

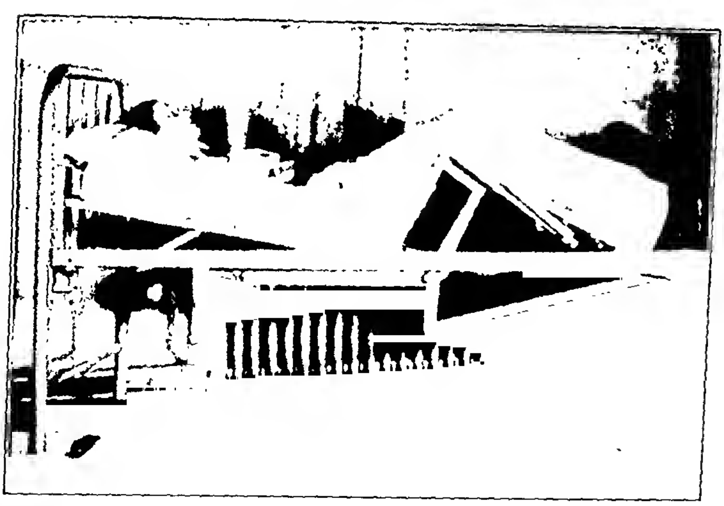

Fig. 9

Flexion attitude employed in relieving acute cases. A similar attitude is advised as a permanent sleeping position for those who suffer at night.

The author is opposed to most manipulations on these patients, particularly any form which involves a stretching of the hamstrings or an extension of the lum-

bosacral spine. The nature of the lesion itself contra-indicates any such action. In fact, at no time during the course of treatment should these patients be permitted to extend the spine.

In acute cases the muscle spasm may be so severe that the desired flexion cannot be obtained. It is well in such cases to remove the cast after a period of ten days and to reapply it. Symptoms have usually subsided considerably and flexion can be more readily obtained. Occasionally it is necessary to remove the cast and to fix the patient with the knees drawn to the chest in order to obtain relief from symptoms. Traction on the affected extremity is frequently an aid in that it may help to open the foramen on that side; however, flexion should not be sacrificed for its use.

After the patient has been ambulatory for from one to two weeks in a flexion cast, the cast is removed and a lordosis brace is substituted. The brace should be so designed as to maintain the eradication of the lordosis of the lumbosacral spine. Such a brace will be described in Part II of this paper. There are some cases in which an orthopaedic corset is sufficient. However, while such garments give partial fixation, they do not afford any appreciable eradication of the lumbosacral lordosis and in many cases they actually interfere with the patient's voluntarily maintaining the corrected position.

Patients past the age of forty-five should be instructed to wear the brace for from six to twelve months. This permits time for the lumbosacral angle to become reduced and partially fixed in the corrected position. These patients should be instructed in postural exercises, in order to obtain a balanced muscle tonus, and should be taught proper positions, both of which will be described under the treatment of the chronic traumatic destruction of the intervertebral disc in Part II.

The length of time during which the brace is worn by patients under the age of forty-five depends considerably on the posture of the patient. The average length of time is from three to six months.

The patient under forty-five who presents an exaggerated lordosis of the lumbosacral spine offers a better prognosis for the prevention of recurrent attacks than those with good posture. This is due to the fact that in eradicating the lordosis in the former group the pelvis rotates forward through a greater arc than in the latter, thereby affording a wider restoration of the posterior width of the lumbosacral foramina. However, unless premature degenerative changes have taken place, all patients under forty-five are given a strenuous course in postural exercise and instructed in positions. As soon as an eradication of the lumbosacral lordosis has been obtained and can be maintained voluntarily, and when the patient thoroughly understands the mechanics of his lesion, the brace can be discontinued.

The young individual whose roentgenograms show a complete loss of the lumbosacral disc and whose clinical examination reveals a good posture—that is, a practically straight lumbosacral spine—presents the

most difficult problem in obtaining satisfactory relief from symptoms by conservative methods. Recurrent attacks are liable to be frequent in this type of case, and surgical measures may have to be employed.

Women frequently object to wearing a metal brace and for this reason corsets have to be used. When it is evident that a better means of fixation and correction is indicated, a light celluloid jacket can be made from a mold taken with the lordosis reduced. This is best accomplished by having the patient sit on an ordinary operating-room stool, with the feet propped up so that the knees are slightly higher than the hips.

When symptoms are confined to one extremity, an elevation of one-half an inch on the heel of the unaffected side frequently aids remarkably in relieving symptoms. This is due to the fact that such a lift tends to open the lumbosacral foramen on the opposite side. However, such a lift must be employed with caution, as it also tends to constrict the lumbosacral foramen on the unaffected side and in a few cases the writer has seen symptoms shifted from one extremity to the other as a result of its use.

In those cases in which all forms of prolonged conservative treatment fail, surgical treatment is indicated. In this series of cases thirty-six operations have been performed. Five were for spondylolisthesis; seven, for lumbosacral anomalies; three, for an anomaly plus a reduced lumbosacral joint space; one, for fragmentation of the inferior fifth lumbar facet, probably traumatic; and twenty, for destruction of the lumbosacral intervertebral disc, three of which were due to tuberculosis and the remaining seventeen, with the exception of one, the author believes were due to acute rather than to chronic injury.

Of the latter group nine were treated by lumbosacral fixation alone, while eight were treated by lumbosacral fixation and removal of the lumbosacral facets on the side principally affected. In two cases the fixation and the facetectomy were done at different stages. The facetectomy was resorted to because the fixation failed to give relief from symptoms referable to the fifth lumbar nerve. Lasting relief has been obtained in all of the seventeen cases with the exception of one in which the patient died after the operation, due to a streptococcal infection of the blood stream.

When symptoms are segmental in character, the author is of the firm belief that the operation indicated in these cases consists of fixation of the lumbosacral spine and opening of the foramen by removal of the facets on the side principally affected. Differing from the former report by Dr. Yglesias and himself, the writer advises that the fusion and the facetectomy be done at the same time, thereby avoiding the second operation in cases where fusion alone fails to give relief. In those cases in which pain has always been confined to the lower part of the back and in which clinical examination fails to reveal any evidence of peripheral nerve changes, lumbosacral fusion alone is indicated.

From the clinical findings and the operative results, the author finds no justification for including a fusion of the sacro-iliac joint unless a de-

velopmental imperfect fusion of the sacral lateral masses is also present. Operative results and procedures in the other cases will be discussed under their proper classification.

Aside from the orthopaedic treatment of these patients, a conservative program should consist of removal of all definite foci of infection, as they are contributing factors in the production of symptoms in any mechanical lesion of the skeletal system. However, pain in the lower part of the back and in the extremities is not an indication for the removal of uninfected teeth, tonsils, or the appendix. Neither is it an indication for questionable pelvic operations, until thorough clinical and roentgenographic examinations of the lumbosacral spine have failed to reveal evidence of pathological change.

All such patients should be examined by a neurologist before surgery is done; however, a thorough knowledge of the lesion under consideration and careful clinical and roentgenographic examinations will differentiate a neuralgia or neuritis of the fifth lumbar nerve from a primary cord lesion. The writer has never seen tabes, diabetes, pelvic tumors, or circulatory changes cause symptoms characteristic of this lesion.

We must constantly bear in mind that there may be more than one lesion of the low spine causing symptoms. The lumbosacral intervertebral disc frequently gives way and undergoes a degenerative change in those cases presenting a lumbarization of the first sacral segment, as well as in those cases showing an imperfect fusion or failure of fusion of the lateral masses of the first and second sacral segments. In such cases, in addition to the pain referable to the fifth lumbar nerve, the patient may complain of symptoms and may present nerve changes throughout the distribution of the first, second, and third sacral nerves. These findings will be discussed under their proper classification.

A thorough knowledge both of the motor and of the sensory distributions of the lumbar and sacral nerves is essential in making an intelligent diagnosis in these cases.

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THE T-SHAPED FRACTURE OF THE LOWER END OF THE HUMERUS

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Although this fracture has not received very much attention in the English and American literature during the last fifteen years, it is a reasonably common injury and there are at least four recognized methods of treating it, all of which differ very widely in their application.

The author has recently reviewed fourteen cases of this type of fracture which were treated by a method first recommended by Hugh Owen Thomas and later popularized by Sir Robert Jones, and the results have been so satisfactory that it has not been considered wise to adopt any of the more modern means of reduction and splintage which have the disadvantage that they are difficult to apply and serious complications are not unknown.

The treatment is carried out in the following manner: Under general anaesthesia, the displaced fragments are manipulated into a better position by means of strong traction which the operator applies by gripping the forearm in the upper third while the patient's elbow joint is held at a right angle. At the same time, the fracture is compressed laterally in an attempt to close the gap between the two condyles. The wrist is then slung from the neck in a collar and cuff or halter, the angle between the forearm and humerus being not less than 60 degrees and not more than 90 degrees. No form of bandage or of compression is applied around the elbow itself, nor is the humerus bandaged to the side of the body. It is most essential that the patient should walk as soon as possible, for the success of the treatment depends more on the gradual traction by the force of gravity than it does on the preliminary reduction, which can frequently be omitted without endangering the end result.

Movements of the fingers and hand are encouraged from the first day, but, as the fragments are naturally very mobile, the shoulder joint is not moved during the first fortnight. After this period, union is becoming firm and routine exercises are given to prevent stiffness from occurring in the shoulder. At the same time, gentle active movements at the elbow joint, from the position in which it is fixed toward the position of full flexion, are permitted, provided that these movements are painless. In a month to six weeks from the date of reduction, free movement, from almost full flexion to as far as the right-angle position, will be present in the elbow joint. If this movement is free and painless and there is no tenderness on pressure over the site of fracture, the patient can dress normally, passing his injured arm through the sleeve of his clothes. He must be encouraged to use his arm, in the attempt to increase the extension of the elbow without losing the free flexion which he has already obtained. A sling is carried outside the clothes in which the arm is rested

FIG. 1-A

Patient S. D., aged sixteen years, a fitter. Roentgenogram taken on August 2, 1934. Reduction was not attempted. Treatment consisted of a collar and cuff with the elbow at an angle of 60 degrees.

FIG. 1-B

Patient S. D., June 27, 1936. Full flexion and rotation: extension limited by 20 degrees; slight loss of the carrying angle.

for frequent short intervals, as it has been found that too rapid an increase toward full extension only causes a diminution of the more important range of flexion. Massage and passive movements should never be advised at any stage of the treatment, but supervision of the exercises is frequently necessary to avoid disappointment, due to inability on the part of the patient to realize the importance of active movement.

Failure to obtain a satisfactory range of movement may occasionally follow the use of this method just as it may occur after any other type of treatment. The causes of these occasional failures may be attributed to gross destruction of bone involving the head of the radius and the surrounding soft tissues, or to lack of cooperation or misunderstanding of instructions on the part of the patient, or to some slight error occurring in the course of the treatment. The mistakes most commonly seen in the carrying out of this method are:

Fig. 2-A

Patient W. B., aged thirty-seven years, a collier. Roentgenogram taken on March 20, 1930. Treatment consisted of a collar and cuff only with the elbow fixed at an angle slightly less than 60 degrees.

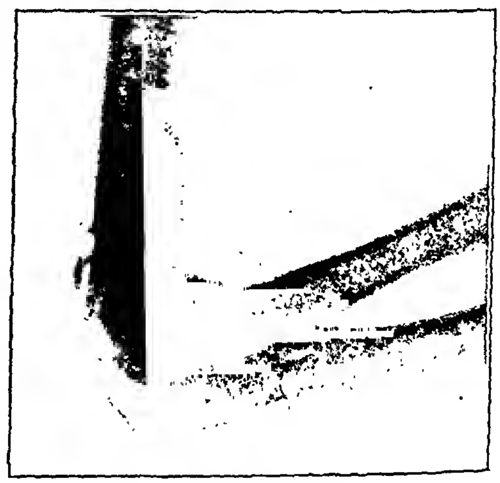

Fig. 2-B

Patient W. B., May 29, 1930, showing the improvement in the position of the fragments, caused by the action of gravity in an ambulatory patient.

1. Fixation of the elbow at too acute an angle of flexion at the commencement of treatment, causing the coronoid process to force apart the fragments of the lower end of the humerus.
2. Too long a period of immobilization after bony union has begun.
3. Pressure from overlying clothes which are used to give support for the elbow and which interfere with the free action of gravity on the joint.

Any one of these simple mistakes will cause some loss of movement, particularly *that of* extension, and to overcome this disability further treatment is sometimes necessary. This is carried out after bony union is firm and when there has been no increase of extension for over two months. The treatment consists of gently forcing the elbow into as much

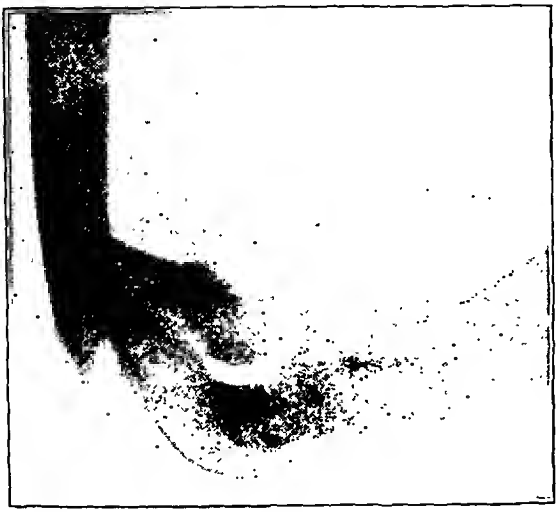

Fig. 3-A

Patient T. S., aged seventeen years, a collier. Roentgenogram taken on August 29, 1933. Reduction under general anaesthesia was attempted, followed by the application of a collar and cuff with the elbow at an angle of 60 degrees.

Fig. 3-B

extension as possible with the patient under general anaesthesia to relax the muscle spasm. When the elbow has been straightened as much as possible, the position is maintained by a plaster slab or metal splint which is kept in place for a fortnight. After this time, the support is removed and the patient is made to use the elbow frequently in order to regain the position of full flexion; at the same time care should be taken to preserve the maximum extension obtained by the manipulation. For an additional four to six weeks the patient wears the support at night to avoid contraction of the tissues in front of the elbow joint during the hours of sleep. This secondary treatment, if carried out gently but firmly when bony

Fig. 3-C

Fig. 3-D

Patient T. S., June 11, 1936. Full movement in all directions; no deformity. Patient back at regular work.

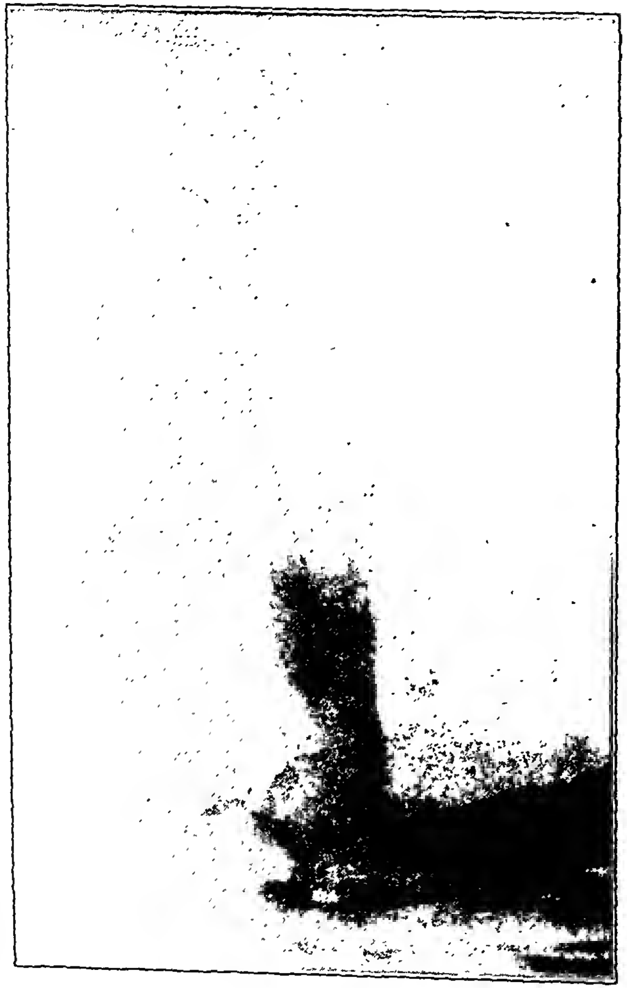

FIG. 4-A

Patient J. G., aged thirty-nine years, a steel erector. Roentgenogram taken on April 9, 1931. Reduction under general anaesthesia was attempted, and the elbow was fixed at an angle of 70 degrees.

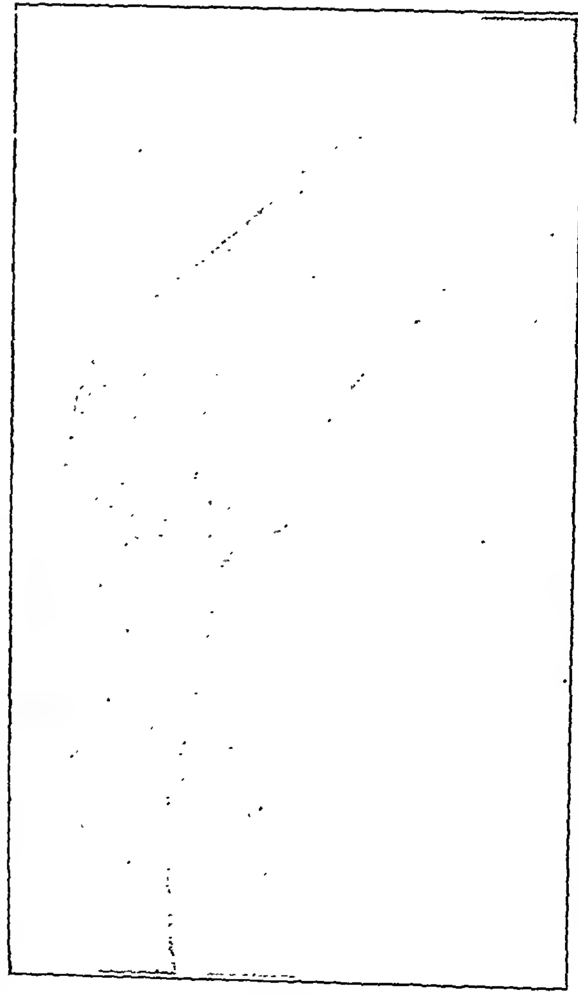

FIG. 4-B

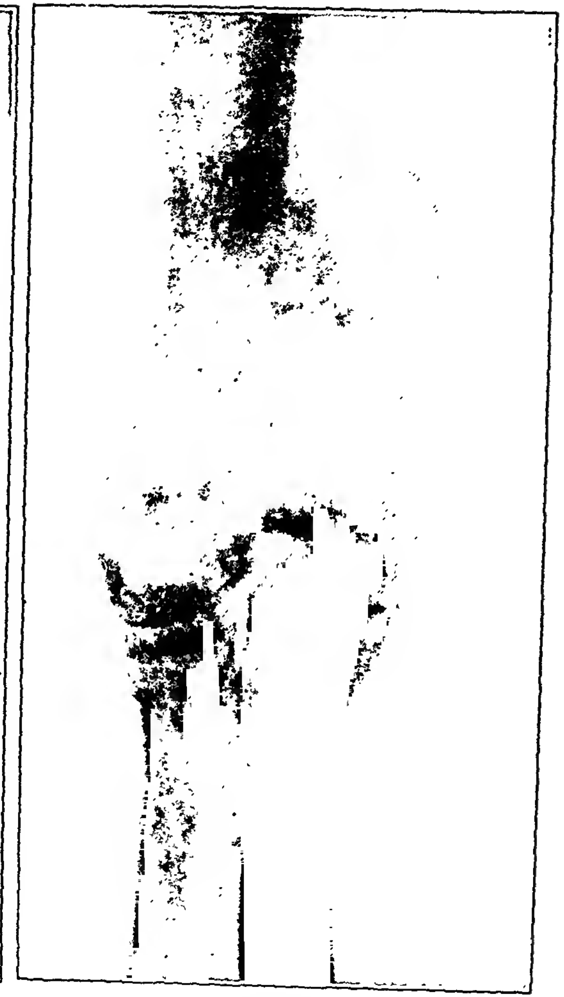

FIG. 4-C

Patient J. G., June 11, 1936. Full flexion limited by 10 degrees; full rotations; extension limited by 30 degrees.

union is sound, never causes any damage to the joint and results in a considerable improvement in the movements of the elbow.

In all of the fourteen cases of this injury, treated by the method described, there was displacement of the fragments. There has not been included in this series any case in which the injury caused no disturbance of the normal line of the bone. The patients' work embraced most forms of employment,—one sailor, one housewife, two engineers, two painters, one publican, five miners, one carter, and one schoolboy. With two exceptions all of these patients have been able to return to their original work without suffering any noticeable incapacity as a result of the injury.

Of the two exceptions, one patient is a painter who, in addition to the fracture of the elbow, sustained a fracture of the occipital and parietal bones with severe concussion. Following the accident, a parkinsonian syndrome developed, which interfered with the treatment and which now prevents him from climbing ladders. The result in this case was undoubtedly the worst of the series, extension being limited by 45 degrees and the last 30 degrees of full flexion being destroyed. This poor result can be easily explained by the absence of the action of gravity on the fragments during the early stages of treatment, due to the necessity for keeping the patient recumbent owing to his severe head injuries.

The other patient who has not returned to work is a collier whose elbow made a good recovery, but who is a semi-invalid suffering from disseminated sclerosis.

Although the other twelve patients have been able to return to their original work, only one has regained the full range of movements. In all the other cases, flexion and rotations are perfect, but there has been some loss of full extension. In three cases there is a loss of from 10 to 15 degrees of full extension; in six, the last 30 to 35 degrees of complete straightening of the elbow has been destroyed; and in three this movement has been limited by 45 to 60 degrees. Although the patient whose extension is limited by 60 degrees works as a painter and paper-hanger and, according to his statement, has suffered no disability, the result would undoubtedly have been more satisfactory if the mistakes mentioned earlier in the paper had not been made. In this case, after the swelling of the elbow had subsided, the limb was fixed in complete flexion for six weeks and the elbow was supported by means of a sling. One of the other two patients sustained a fracture of the external condyle of the humerus when a small boy, and extension of the elbow had ever since been limited by 45 degrees.

The number of cases reviewed for this paper is undoubtedly small, but the results show what can be done by a method so simple and so free from risks that anyone can carry it out with safety and confidence. In addition, it emphasizes once more a principle which tends to be forgotten in these days when so much dependence is placed upon evidence given by the roentgenogram,—namely, that function is of more importance than roentgenographic appearances and a perfect anatomical reduction is not necessary in order to obtain a good result.

HALLUX VALGUS

BY CHARLES F. PAINTER, M.D., BOSTON, MASSACHUSETTS

So many people are subject to bunions and to the more serious degrees of the deformity known as hallux valgus, of which a bunion is almost invariably an accompaniment, and so gratifying are the results of both conservative and radical treatment in appropriate cases, that a few observations growing out of long experience with cases of this sort do not seem amiss. It is a common lay belief that when one has this *deformity* it has been caused by wearing a short shoe at some time. If by a "short shoe" is meant one in which the toes come too near the box on the shoe, this is not necessarily true. If, on the other hand, is meant a shoe in which the vamp is cut too low—that is, too near the great-toe joint—then that sort of a "short shoe" is very probably a conspicuous causative factor. Under such circumstances, the great-toe joint is so placed on the last that the leather pushes the great toe over toward the other toes as the last narrows toward the box, and, when the box is reached, its more rigid leather is even more insistent upon crowding the great toe away from the median line. Every time such an individual steps forward in his stride, he tends to thrust the forefoot into a narrowing pocket at the end of the shoe and consequently the great-toe joint and sometimes the corresponding joint of the fifth toe are chafed by the leather over these articulations.

The commonest causes for maladaptation of the foot to ready-made shoes, aside from the variations brought about through changes in the styles of footwear, are the anatomical variations in the make-up of the tarsus and the metatarsus. These changes are more common than is generally realized. The late Dr. Thomas Dwight called attention to these by pointing out that variations amounting to one-half an inch in the lengths of the first metatarsals were not at all uncommon and, where such variations occurred, they were compensated by a corresponding shortening or lengthening of the articulating phalanges.

One of the consequences of this would naturally be to place the metatarsophalangeal joints nearer to the point where the last of the ready-made shoe begins to narrow toward the tips of the toes or to push it back more nearly beneath the seam that marks the juncture of the vamp with the upper. In the first instance, this means that the great toe will be crowded over toward the outer side of the last and a hallux valgus may develop, and, in the second instance, that pressure on the dorsum of the metatarsal head may ultimately result in a hallux rigidus.

If these situations were recognized sufficiently early, there would be no crippling deformities and no necessity for surgical treatments. Insistence upon a straight inside line to the last and location of the first metatarsophalangeal joint from one-half an inch to three-fourths of an inch in front of the juncture of the vamp with the upper should avoid these

difficulties. This would mean that the great-toe joint would be at about the same distance behind the posterior edge of the box as it is in front of the vamp. If this condition cannot be met by a ready-made shoe, the need for a custom-made one is imperative.

If a beginning hallux valgus cannot be slightly overcorrected manually, the author doubts that any shoe or toe post will prevent a progression of the deformity to a state where operative correction will not be necessary. In the case of hallux rigidus it is his belief that a properly made shoe will permanently relieve all subjective symptoms and only in very exceptional circumstances will operations be in order.

When it comes to the choice of surgical measures in the treatment of hallux valgus, the writer is convinced that the simpler the procedure, the better, provided it is recognized that the deformity is not the result of any sort of an exostosis on the inner aspect of the first metatarsal head. Occasionally, there may be complicating hypertrophic arthritic changes here, and in certain severe acute infections there may be proliferative osseous lesions, as in Neisser infections. In neither of these cases, however, should operations be performed. Procedures that contemplate slicing off the inner border of the metatarsal head, or transplanting tendons to adduct the proximal phalanx, or rendering the operation more surgical by complicating an excision of the metatarsal head by an arthroplasty, or fracturing the shaft of the first metatarsal to correct abduction do not meet the anatomical conditions present in a hallux valgus, or, if they do, they do it in an unnecessarily complicated fashion.

There are no methods of attacking the problem surgically that are not open to some objections. The method devised long ago by Hueter has always appealed most strongly to the author and, unless some essential has not been performed satisfactorily, he has had no reason to regret his adherence to its fundamentals. It has been criticized most often because it has been thought that the anterior arch must be weakened by the removal of one of its abutments. Whereas this would appear to be a reasonable objection, the fact remains that, when the proper after-care has been provided, no such impairment is in evidence.

For the benefit of those to whom this problem is not presented often enough to give them a large clinical experience in dealing with it, one may perhaps be excused for emphasizing certain details of this operation of Hueter's. The first essential is the removal of enough of the metatarsal head. The skin incision should be centered over the line of the joint and should curve with its convexity toward the dorsal surface of the toe and in this convexity should lie the bursal enlargement, if there is one. The bursa should be dissected out of the skin flap, care being exercised not to "buttonhole" the skin. After the bursa has been removed, the fascia is incised to the bone (first metatarsal) and stripped back, by blunt dissection, over the entire circumference of the bone to a distance of at least one-half an inch posterior to the line of the proposed osseous incision. Then, with a saw-tooth chisel having, for the operator's comfort, a broad

head, the bone incision is made clear through from the inner aspect of the metatarsal to and through the outer cortex. The incision should be placed at about one-fourth of an inch anterior to the level where the metatarsal shaft begins to expand to form the head of that bone. Secondly, this osseous incision should be made at right angles to the long axis of the shaft of the metatarsal.

The operator should not yield to the temptation to complete the excision by fracturing this outer cortex by prying off the head. If done in this way, there will be spiculation of the end of the metatarsal, a fruitful source of painful after-symptoms. The phalanx, of course, is not disturbed. It should be obvious that this amount of bone cannot be removed from the capsule of the joint and no provision made to counteract the tendency of the phalanx to assume a position in which the horizontal plane of the plantar surface of the metatarsal and that of the phalanx are not still continuous. This is provided for in the application of the dressing after the capsule has been closed with three or four chromic catgut sutures and the skin with a continuous dermal suture.

To accomplish this, a sterilizable German-silver splint may be fashioned, so as to exert pressure upon the dorsal surface of the proximal end of the phalanx, and curved in such a way that adduction of the great toe may be accomplished at the same time. These splints may be made up in rights and lefts, requiring very little adjusting for any adult. In the absence of this splint the same object may be achieved with an unfolded gauze sponge, one end of which encircles the proximal end of the phalanx; as it is applied, the toe may be forcibly flexed and adducted, and a gauze plug should be inserted in the cleft between the great and second toes. This must be kept in place during the two to three weeks required for contraction of the capsule. In this way will be avoided the upriding of the phalanx upon the metatarsal, a situation that marks failure to attend to this detail. Weight-bearing should not be permitted for three weeks and, as a rule, it will be another three weeks before the patient can get his own shoe on and walk with reasonable comfort.

If this plan is followed conscientiously, one may predict a satisfactory result, functionally and otherwise.

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SUBASTRAGALAR DISLOCATION

A Report of Seven Cases *

BY HUGH SMITH, M.D., MEMPHIS, TENNESSEE

From the Willis C. Campbell Clinic

Subastragalar dislocation is not so rare as the total number of cases reported would lead one to assume. Shands in 1928 reviewed the literature; he found 138 cases and added one of his own, which was the first in the records of the Johns Hopkins Hospital. Of 1,089 fractures of the ankle over a period of nine years, Stimson reported only five subastragalar dislocations over a similar period of time. Straus in 1935 emphasized the infrequency of this lesion, stating that only 148 cases had been recorded in the 123 years since Judcy and Dufaurest reported the first two cases in 1811.

On the assumption that the rarity of this lesion was exaggerated by a paucity of reports and that the number of cases reported was not commensurate with the actual occurrence of this lesion, 535 consecutive dislocations of all types from the Willis C. Campbell Clinic were reviewed. Seven subastragalar dislocations were found, the incidence of occurrence being 1.3 per cent. The records of the Memphis General Hospital revealed three subastragalar dislocations over a period of fifteen years, but these are not included in this report.

No age group is exempt from this dislocation. Six cases are reported in the literature in which the patients were over sixty years of age. Included in this report is the case of a child aged ten. The incidence is six times greater in males than in females, which is commensurate with the etiology,—violent trauma.

The types of dislocation may be described as inward, outward, backward, and forward. The lateral displacement of the foot is usually associated with varying degrees of posterior or anterior displacement and may be classified as external and anterior, medial and posterior, etc., but this is of more academic interest than of practical importance. Therefore the seven cases herein reported were classified as follows: medial, three cases; lateral, four cases.

One hundred fifty-five cases of subastragalar dislocations, including those herein reported, were analyzed as to the type of displacement, with the following result:

Medial	87 cases
Lateral	52 cases
Forward	6 cases
Backward	10 cases

The medial type is, therefore, more common than the combined total of the other three.

* Submitted for publication July 16, 1936.

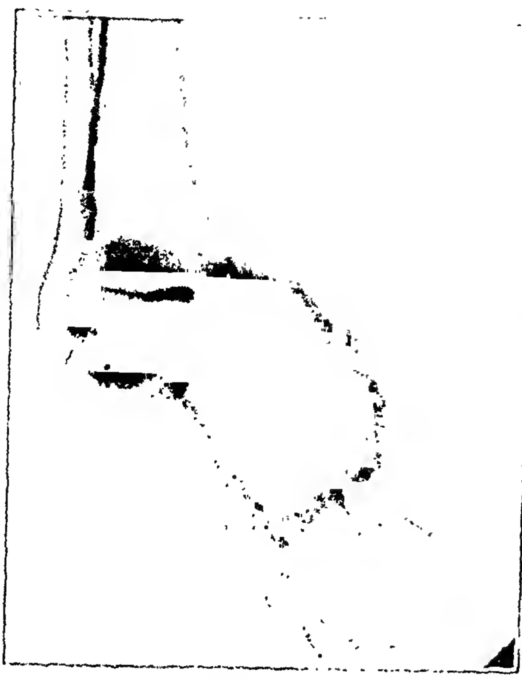

Fig. 1-A Fig. 1-B

Case 1. Medial subastragalar dislocation.

The functional relationship of the astragaloscaphoid and the astragalocalcaneal joints manifests itself in subastragalar dislocations, as there is an accompanying dislocation of the astragaloscaphoid joint.

The medial type of dislocation, which is the most common, is produced by a combined, violent plantar flexion, adduction, and supination of the foot, while the astragalus is carried forward and laterally by a force acting through the tibia and the fibula. The joint capsule and the dorsal astragaloscaphoid ligaments are torn, and the head of the astragalus is displaced upward and laterally from its articulation with the scaphoid, as the astragalocalcaneal ligaments are ruptured and the os calcis is displaced medially. The head of the astragalus rests upon the cuboid or upon the articulation between the cuboid and the scaphoid. If the force is extreme, the os calcis, the cuboid, and the scaphoid may be medial to the internal malleolus.

In the lateral type the dislocation is produced by abduction and pronation. The tibioscaphoid and calcaneoscaphoid ligaments and the joint capsule are ruptured with medial and forward displacement of the astragalus and lateral displacement of the remaining tarsal bones after rupture of the astragalocalcaneal ligaments. The head of the astragalus lies parallel with and overlaps the medial side of the scaphoid.

Complete relaxation is a necessary prerequisite to successful closed manipulations. Briefly, reduction may be accomplished by exaggerating the existing deformity, and then reversing the forces which produce the dislocation with traction on the foot and direct pressure on the head of the astragalus. The knee is flexed to relax the tendo achillis. A normal contour is restored with an audible snap.

In cases of extreme lateral or medial displacement, numerous attempts at closed manipulation may fail. The extensor tendons to the toes, the posterior and anterior tibialis tendons, and the capsule or ligaments adjacent to the astragaloscaphoid joint may become looped over the head and neck of the astragalus in such a manner as to prevent reduction. After proper exposure and incision of these structures, reduction is easily accomplished. This was true in two of the five fresh cases of this series.

Old unreduced dislocations require a complete reconstruction of the tarsal joints. In Case 7 the scaphoid and the head of the astragalus were removed with arthrodesis of the subastragalar and calcaneocuboid joints and the remaining portion of the astragalus to the cuneiforms, with an excellent functional result.

CASE REPORTS

Case 1. A white woman, aged forty-nine, was struck by an automobile and sustained an injury to her right ankle. Roentgenograms (Figs. 1-A and 1-B) revealed a medial subastragalar dislocation with a fracture of the fifth metatarsal bone. Closed manipulation was unsuccessful. A large mass of ligamentous tissue was found to be looped over the lateral side of the head of the astragalus in such a manner as to prevent reduction. Reduction was easily accomplished after removal of this obstruction. (See Figures 2-A and 2-B.) An excellent functional result was obtained.

Case 2. A white woman, aged thirty-five, injured her right ankle in an automobile accident. Examination showed a lateral subastragalar dislocation (Figs. 3-A, 3-B, and 3-C). At operation the head of the astragalus was displaced across the tibioscaphoid and calcaneoscaphoid ligaments. Following immobilization in a boot cast for four weeks (Figs. 4-A, 4-B, and 4-C), extensive physical therapy was instituted. Four months later the range of motion in the foot and ankle was practically normal.

Fig. 2-A

Fig. 2-B

Case 1. After reduction.

Fig. 3-A Fig. 3-B

Case 2. Lateral subastragalar dislocation with marked forward displacement of foot.

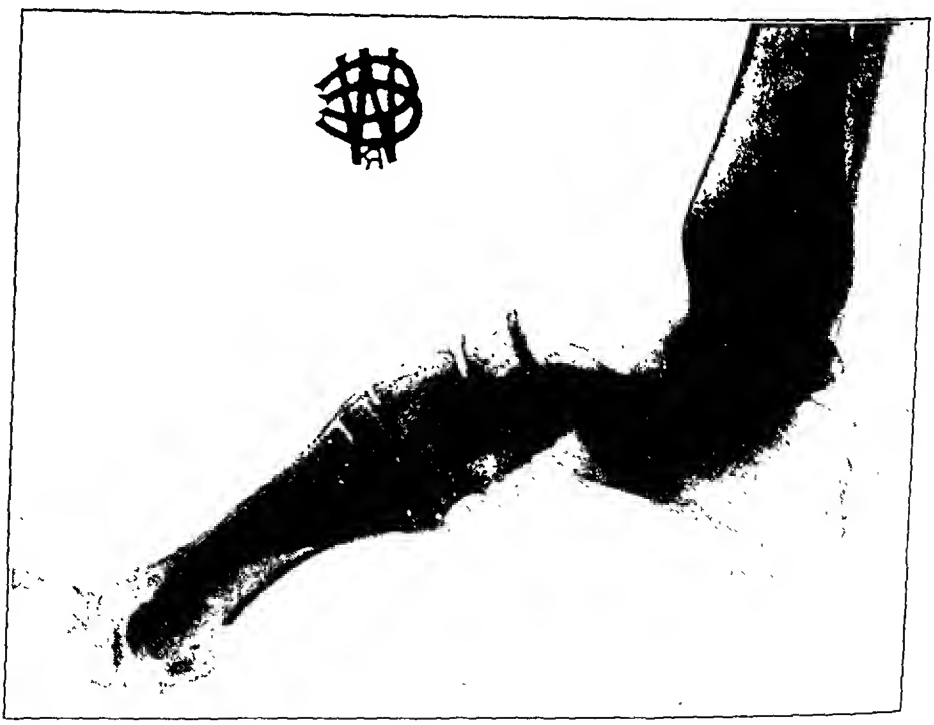

Fig. 3-C

Case 2. Lateral view, showing subastragalar dislocation.

FIG. 4-A FIG. 4-B

Case 2. After reduction.

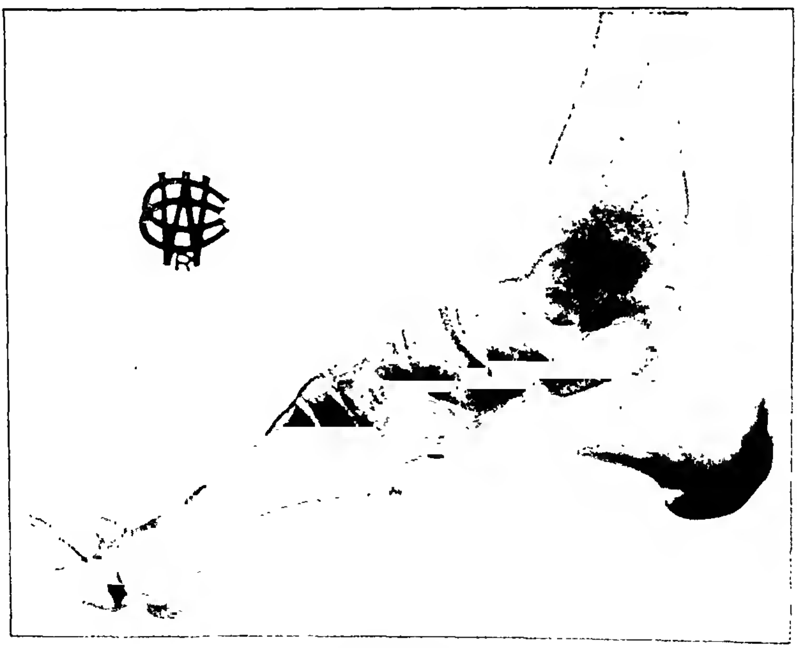

FIG. 4-C

Case 2. Lateral view after reduction.

CASE 3. A white woman, aged thirty-two, was admitted with the left foot in marked supination and the forefoot at a right angle to the anterior posterior plane. The astragalus was protuberant laterally. (See Figures 5-A and 5-B.) The injury was the result of an automobile accident. This medial subastragalar dislocation was reduced by closed manipulation. (See Figures 6-A and 6-B.) Five months later function was excellent except for slight limitation of motion in abduction and adduction.

CASE 4. A white man (age not recorded) was seen in consultation for a severe in-

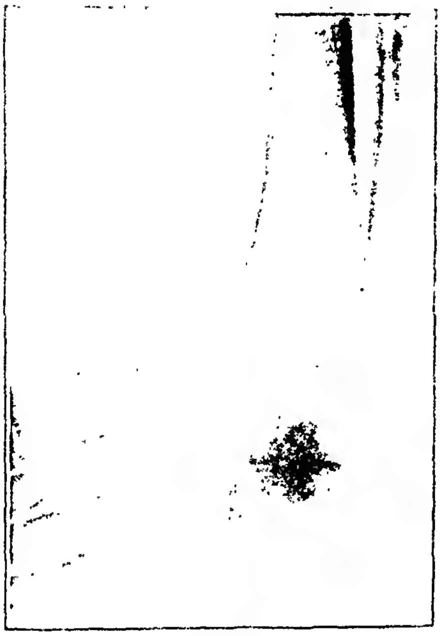

FIG. 5-A

FIG. 5-B

Case 3. Medial subastragalar dislocation with foot at right angle to normal position.

FIG. 6-A

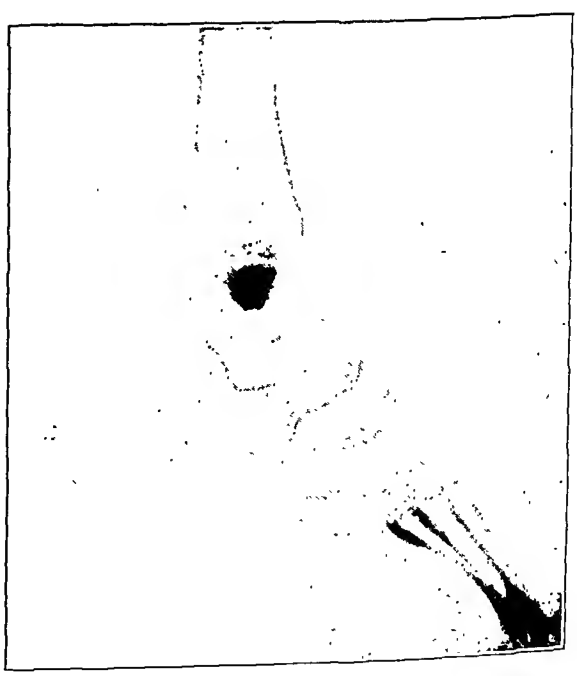

FIG. 6-B

Case 3. After reduction.

jury to his right foot, received while working in an elevator shaft. Roentgenograms revealed lateral displacement of the tarsal bones at the subastragalar joint; the astragalus was in its normal relationship with the tibia. There was a chip fracture of the external malleolus, as well as a fracture of the neck of the os calcis with slight displacement, and a line through the posterior surface of the astragalus suggested a fracture without displacement. The end result is unknown.

Case 5. A white man, aged twenty-five, had injured his foot and ankle fifteen years previous to admission, when a horse had fallen on him. After long hikes while in the Army he had had marked pain and swelling. At examination, the foot was found to be cyanotic with marked limitation of motion in all directions. There was lateral displacement of the foot at the subastragalar joint, and the patient stood with the foot in moderate pronation. A subastragalar fusion was advised, but refused.

Case 6. A white man, aged forty, sustained an injury to his foot when a porch fell. He did not know whether the injury was due to falling material or to his own weight.

Fig. 7-A

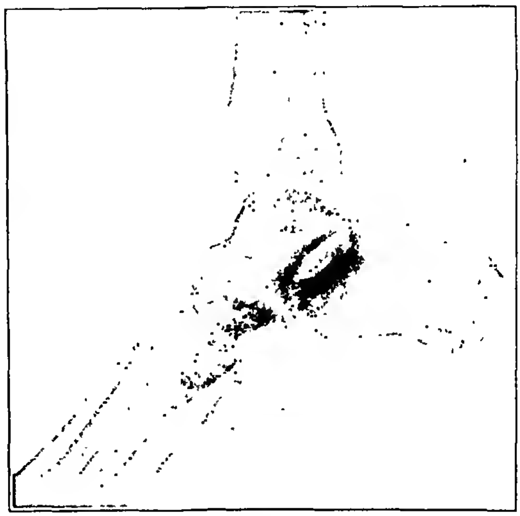

Fig. 7-B

Case 7. Old reduced lateral subastragalar dislocation.

Fig. 8-A

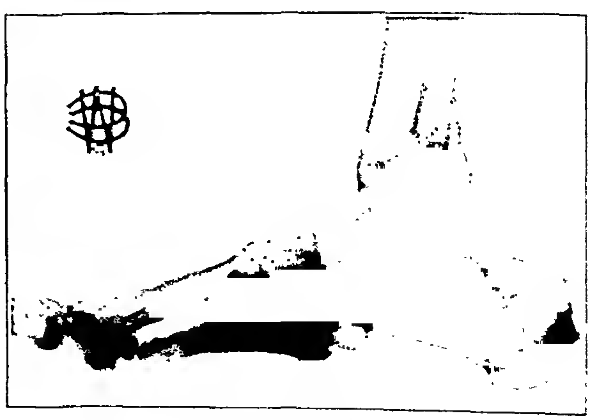

Fig. 8-B

Case 7. After reconstruction and arthrodesis.

There was a medial subastragalar dislocation with a fracture of the head of the astragalus, the loose fragment being displaced upward. The foot was forcibly reduced without difficulty. The end result is unknown.

CASE 7. A white man, aged fifty-two, jumped from a bale of cotton and injured his right ankle. No roentgenograms were made, and the ankle was immobilized in a splint for six weeks. When first observed (Figs. 7-A and 7-B) this lateral subastragalar dislocation was of six months' duration. A triple arthrodesis and reconstruction operation were done. (See Figures 8-A and 8-B.) Recently, after six years, the patient has again been observed. His weight is 300 pounds and he walks all day without symptoms.

SUMMARY AND CONCLUSIONS

In a review of 535 dislocations, seven subastragalar dislocations were found, the incidence of occurrence being 1.3 per cent. It was found that with prompt reduction good functional results could be anticipated. No difference in end results was noted between the cases in which closed reduction was done and those in which reduction was obtained by open operation, although convalescence was somewhat prolonged in the latter cases. Of the seven subastragalar dislocations, an excellent result was obtained in four; the end result in the other three cases is unknown.

Associated fractures of the tarsal and metatarsal bones and of the tibia or fibula, which are common, may complicate treatment and produce permanent disability. A permanent limitation of abduction and adduction of greater or lesser degree may be expected after such violent trauma. Old unreduced dislocations require complete tarsal reconstruction and arthrodesis.

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INJURIES TO THE ACCESSORY PROCESSES OF THE SPINAL VERTEBRAE *

BY MERRILL COLEMAN MENSOR, M.D., SAN FRANCISCO, CALIFORNIA

The successful treatment of low-back pain resulting from trauma depends primarily upon our knowledge of what anatomical structures have been damaged and our recognition of the extent of this damage.

This presentation does not deal with compression fractures, but has for its purpose a discussion of fractures of those accessory processes of the vertebra which constitute the pedicles, the lamina, and the articular facets. Injuries to the lamina, the pedicles, and the articular facets are only discernible by special roentgenographic studies, made at various angles, and are rarely seen in the routine anteroposterior or lateral views.

Although from time to time some mention has been made of fractures involving this area, the paucity of literature on the subject would apparently indicate that these injuries have not received what seems to us due consideration in our routine examinations. It is our belief that these fractures frequently follow torsion injuries and that they give rise to prolonged low-back symptoms.

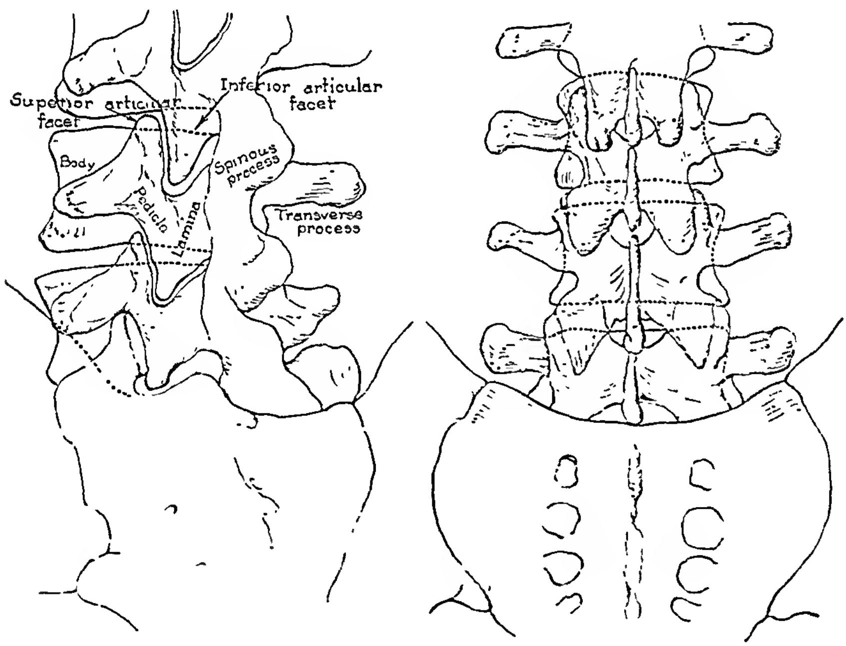


FIG. 1

Tracing of roentgenogram of normal lumbar spine, showing an oblique study and the routine anteroposterior view of the same area.

* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons, Cleveland, Ohio, January 12, 1937.

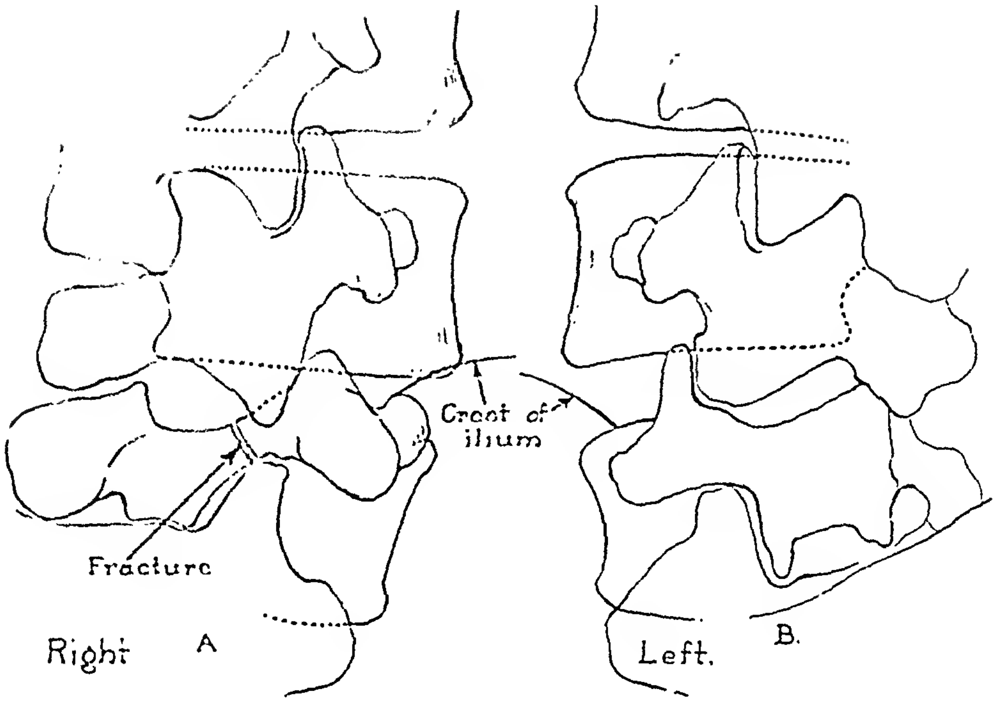


Fig. 2-A

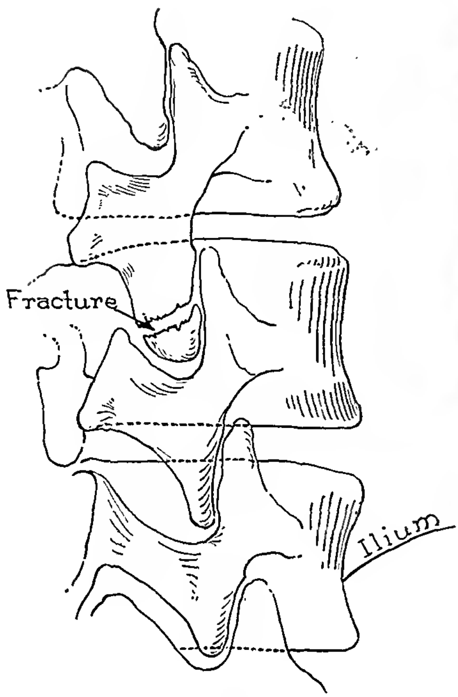
A: Torsion injury with fracture through the base of the lamina.
B: Left oblique view, showing normal bone continuity for comparison.

Fig. 2-B

Reproduction of original roentgenogram. Note the irregularity and the extent of the fracture line.

During the past five years a study of several hundred patients with low-back pain following trauma has led us to believe that fractures of the accessory processes occur both alone and with compression fractures of the vertebral body. We hope with the aid of our illustrations to demonstrate clearly that our opinion concerning the existence and frequency of these fractures is not based on purely theoretical grounds.

It is our belief that torsion plays a prominent part in all injuries to the low back, either acting as a primary force or combined with flexion or hyperextension. That such torsion may well produce injuries to the accessory processes does not seem to us unlikely. The results of torsion stresses on long bones are well recognized. The same type of force acting on the spinal column through the mechanism of a long lever—the



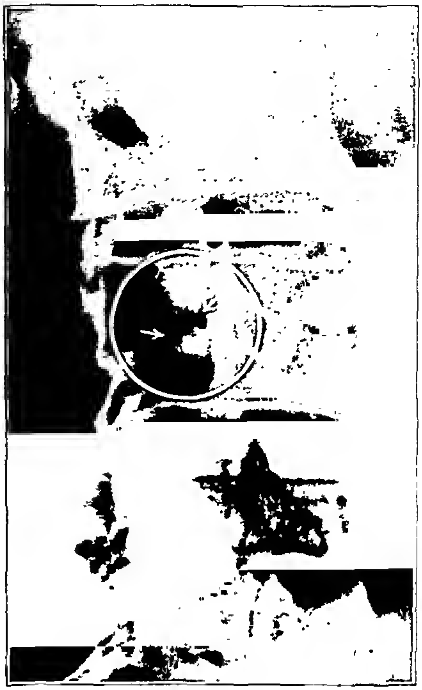


Fig. 3-A Fig. 3-B

Torsion injury followed by fracture of the inferior articular facet of a lumbar vertebra. Note the irregularity of the fracture line with the rotation and displacement of the caudal fragment.

spine and the upper extremities—and a short fulcrum—restricted to the small area of the lamina, the pedicles, and the articular facets—could well exert sufficient force to cause fracture. Depending upon the amount and location of the force exerted, it seems rational that there will result either ligamentous or bony injury similar to that occurring in the extremities. (Examples of fractures caused in this manner are illustrated in Figures 2-A through 5-B.)

We have found fractures of the articular process complicating compression fractures of the vertebra and this may explain the cause of persistent low-back pain found in some patients in spite of perfect anatomical restitution of the gross deformity of the body. (See Figure 6.)

There is no clinical index for the amount of trauma that may be involved in this torsion mechanism, but, as a result of our experience, in cases of severe back strain with persistent localized symptoms, special oblique roentgenograms have shown a surprisingly high percentage of fractures of the accessory processes. We believe the frequency is sufficiently great to warrant the addition of oblique roentgenographic studies as a routine method of diagnosis in any case following trauma in which roentgenograms of the spine are indicated.

Although we would not presume to give accurate statistical data relative to the frequency of these lesions, we have found with our accumu-

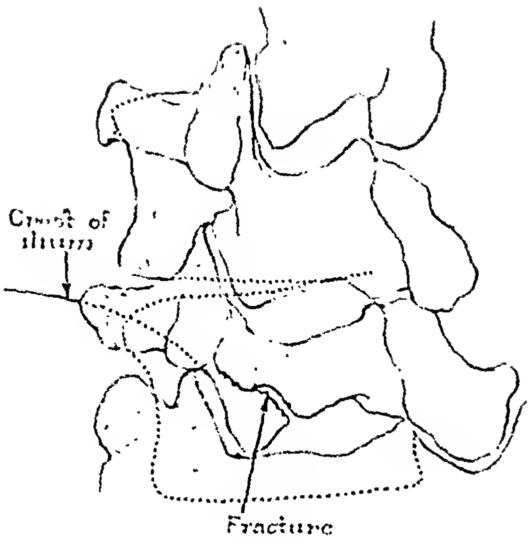


Fig. 4-A

Torsion injury, causing irregular fracture extending from the lamina into the isthmus and the base of the articular facet.

Fig. 4-B

lating experience, as our procedure in taking oblique roentgenograms has changed from the occasional case to an increasing number of complete studies, that the percentage of fractures has become noticeably higher.

As a majority of these injuries are found in ambulatory patients presenting symptoms of acute low-back disability following torsion

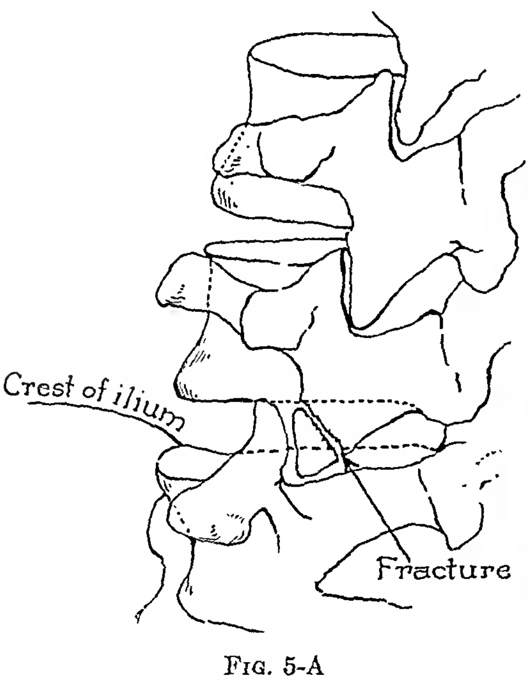


Fig. 5-A

Fig. 5-B

Torsion injury with fracture of the inferior articular facet of the lumbar spine. Note the irregularity and the course of the fracture line, the sharp, clear-cut edges, and the displacement of the fragment toward the opposing articular surface.

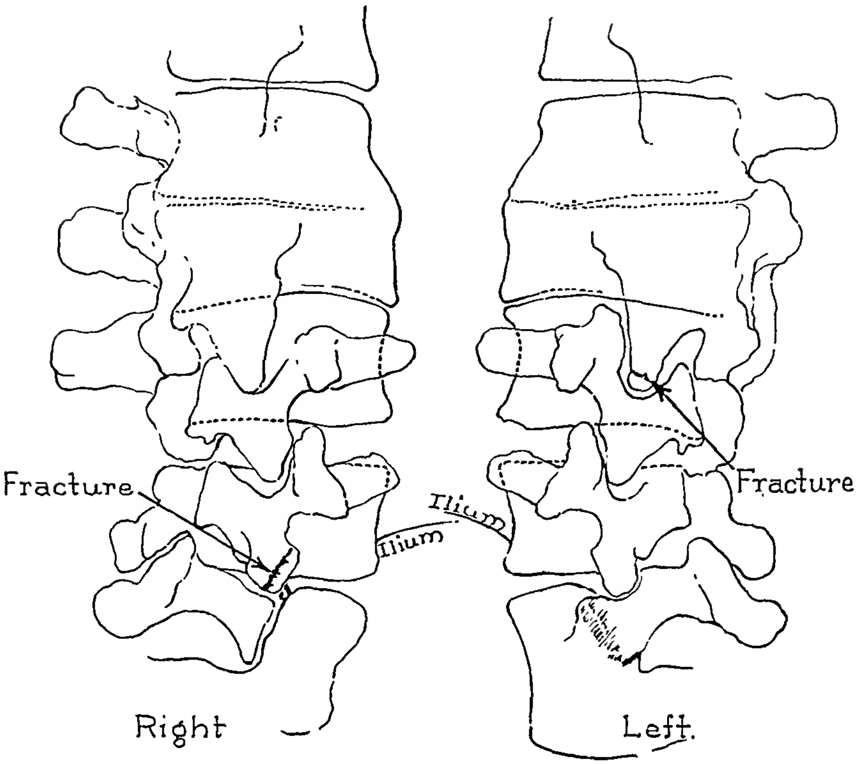


Fig. 6

Tracing of roentgenogram, showing compression fracture of the lumbar spine with fracture of the inferior articular facet in the vertebra below on the left side. Continuation of the torsion force has caused fracture of the base of the pedicle on the opposite side at a lower level.

injuries, some idea of the frequency of their occurrence may be ascertained by the following figures taken from our office records during the past two years. Roentgenographic examination of the low back following injury was deemed necessary in 141 patients; in these cases, sixty-seven oblique studies (approximately 50 per cent.) were made. Twenty-two, or approximately 33 per cent., of these oblique studies showed fractures involving the accessory processes under discussion. There were nine cases (13 per cent.) of anomalies involving the lamina, the pedicle, and the articular facets. The frequency of fractures in these specific accessory processes was about two and a half times greater than the frequency of anomalies.

The difficulty in the recognition of these fractures has been due primarily to lack of development of a proper routine roentgenographic technique for visual demonstration of fractures in these processes. Visualization of such a fracture is only possible by taking roentgenograms at various angles, depending upon the anatomical peculiarities of the particular spine under observation. The essential point is to project the articular facets, the pedicles, and the lamina in detail, in order that minor

abnormalities may be recognized. Stereoscopic studies are of material assistance in this respect.

The roentgenographic technique is simple but time-consuming. Patients with these lesions are uncomfortable in oblique positions and require careful immobilization, as the roentgenograms with fine focus tubes require a relatively long exposure. The planes of the facets of the vertebral articulations are variable in individuals and in different vertebrae and are frequently asymmetrical in the same vertebrae, so that no routine angle of rotation could be satisfactory. A trial oblique study at 45 degrees can be used as a base line, followed by further studies with either an increase or a decrease in angulation until all of the affected accessory processes are visualized.

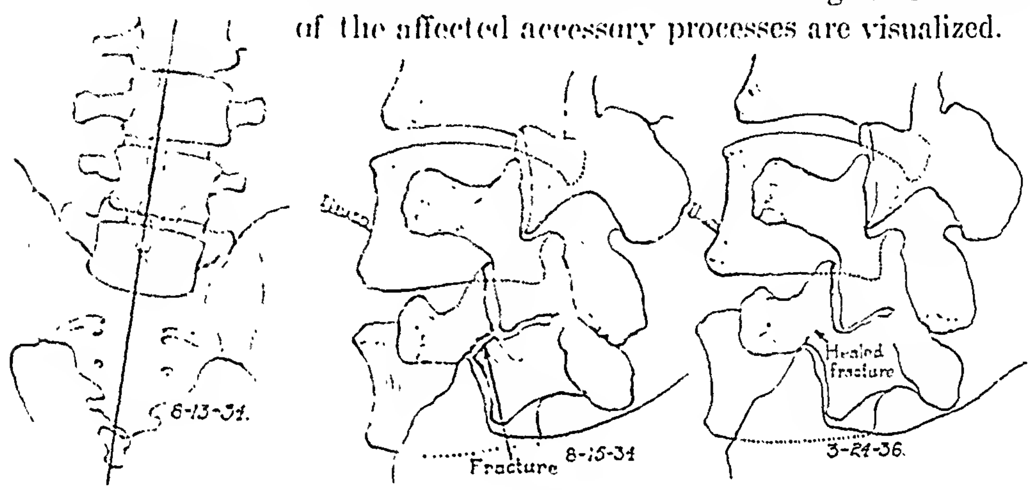


FIG. 7-A

Tracings from roentgenograms of a torsion injury, showing fracture through the isthmus and healing of the fracture one and one-half years later. Note the list of the spine toward the lesion, resulting from trauma to the lateral articulation.

FIG. 7-B

Roentgenogram, August 15, 1934.

FIG. 7-C

Roentgenogram, March 24, 1936.

In the interpretation of these films there comes to mind at once the frequency of the common congenital anomalies and failures of ossification in this area and one must be able to differentiate between these conditions and true fractures.

The common anomalies are seen as defects in the articular facets and failure of fusion of the lamina and the pedicle. These anomalies and fractures may occur in analogous locations. Anomalies can be differentiated by their clear-cut line of cleavage, the smooth, rounded character of the bone edges, and the sclerotic changes at the periphery of the fragments. In contrast to these findings, fracture lines are irregular, in variable planes depending upon the lines of force. They frequently show varying amounts of displacement and rotation of fragments when studied stereoscopically. These fractures followed over a given period will disclose evidence of bone regeneration, in many cases progressing to complete healing as illustrated in Figures 7-A, 7-B, and 7-C; whereas anomalies are stationary without visible change over a similar period.

Early recognition of fractures in this area is important both from the standpoint of differential diagnosis, of treatment, and of prognosis. Early treatment, consisting of moderate ambulatory immobilization over a sufficient period for the promulgation of bony union, offers an excellent prognosis for complete recovery.

The type of immobilization used can be left to the discretion of the attending surgeon, if he bears in mind the following principles: (1) the elimination of large arcs of motion in the affected area and the prevention of torsion and rotation movements; and (2) the preservation of the patient's normal postural curves and the tonicity of his spinal musculature. Braces of light spring steel of the Brackett type and, in some cases, light non-padded plaster jackets have proved quite efficient.

In contrast to the results following early diagnosis and initiation of treatment, undiagnosed, untreated lesions give a relatively high percentage of non-union. Such untreated cases, seen months after the injury, frequently show the fracture ends eburnated and smooth, with evidence of a typical non-union, and having a roentgenographic appearance practically analogous to an anomaly. In such cases it is often impossible to make a differential diagnosis. This roentgenographic appearance may be due to excessive mobility at the fracture site, to peculiarities of the local vascular supply, or to a combination of both. Some pertinent comparisons can be drawn in fractures of the ulna styloid and the carpal scaphoid. The presence of non-union in many cases is a cause of persistent pain. Similar symptoms may also result from a fracture of the articular facet, which has healed with displacement, setting up sufficient joint irritation to develop a traumatic arthritis.

For the permanent alleviation of symptoms in cases of non-union or of malunited articular fractures surgery seems indicated. In some instances a facetectomy will suffice, while others require spinal fusion. However, our experience in this phase of the treatment is too limited at present to draw any positive conclusions.

CONCLUSIONS

1. More complete roentgenographic studies of the spine, made in various planes, will reveal previously undiagnosed fractures of the accessory processes as one of the causes of previously unexplained chronic low-back pain following injury.

2. Early diagnosis, which is only possible by complete roentgenographic examination, and the institution of adequate conservative treatment give an excellent prognosis for complete recovery in simple lesions.

3. Injuries resulting in permanent damage to the articular facets may require surgery for their alleviation.

4. In debatable injuries, early studies with systematic follow-up will demonstrate fractures progressing to complete healing or to sclerotic changes, in contrast to anomalies which are unchanged over a similar period.

5. This study has proved to our satisfaction that fractures of the articular processes are of relatively frequent occurrence and we hope by this presentation to have stimulated sufficient interest for more careful routine investigation of these portions of the vertebral column.

We would not feel this paper to be complete without an expression of appreciation to several of our local colleagues for their interest and cooperation, especially to Dr. Frederick H. Rodenbaugh whose excellent roentgenographic technique has made this presentation possible.

THE PHYSIOLOGICAL METHOD OF TENDON TRANSPLANTATION IN THE TREATMENT OF PARALYTIC DROP-FOOT *

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Just twenty years ago Biesalski and Mayer published their work on the physiological method of tendon transplantation. Although a complete review of the developments of the twenty years is impossible in the confines of this paper, it seems to the author worth while to attempt an evaluation of the treatment of one type of paralytic deformity—drop-foot—by means of tendon transplantation. The cardinal principles of tendon transplantation which were laid down twenty years ago still hold good. These are briefly:

1. Whenever possible retain the normal relationship between the transplanted tendon and the gliding apparatus.
2. Operate with minimal trauma, avoiding injury to the sheath, to the paratenon, and to the delicate gliding cells on the surface of the tendon either by improper handling with instruments, or by undue exposure to the air, or by contact with gauze.
3. Establish adequate mechanical lines of traction, so that the transplanted tendon may be able mechanically to do what is expected of it.

These principles have become so much a part of modern tendon surgery that few surgeons realize their indebtedness to Biesalski who was the first orthopaedic surgeon to utilize the sheath of the paralyzed tendon as a physiological pathway for the transplanted tendon. The development of tendon surgery to its present adequate technique is due largely to this physiological concept worked out by Biesalski.

Of the practical developments since the Biesalski-Mayer publication, the most important in the correction of paralytic foot deformities has been the association of tendon operations with bone stabilization. For five years the author struggled vainly to obtain permanent correction of paralyzed feet by tendon transplantation alone. Then, in 1921, Hoke published his method of stabilization and, through Gill's discussion of this paper, the writer's attention was drawn to the similar operation of G. G. Davis. Thereafter, by combining bone stabilization with the physiological method of tendon transplantation, the problem of securing permanent correction was solved.

Not all cases of drop-foot can be treated by this combined method. Those in which the peroneal tendons, as well as the dorsiflexors, are paralyzed are best treated by the Campbell bone block or by its modifications. In a few instances, the author has supplemented the bone block by trans-

* Read at the Annual Meeting of the American Orthopaedic Association, Milwaukee, Wisconsin, May 20, 1936.

planting the tibialis posterior to the outer border of the foot. This operation, originally described by Biesalski and Mayer, is far less likely to succeed than is the use of peroneal transplants, since the tibialis posterior has to wend a somewhat circuitous course over the mesial surface of the tibia. This not only makes adhesions more probable, but the curving line of traction interferes with strong dorsiflexor action. Despite this obvious disadvantage, both Ober and the writer have secured some excellent results, but in the author's opinion it is not wise to rely upon the tibialis posterior alone to counteract the plantar flexors. This procedure should be used to supplement the Campbell bone block. Putti, in a personal communication, reports the transplantation of the tibialis posterior through the interosseous membrane. To prevent adhesions, he cuts a large window in the membrane. The writer has had no experience with this method, which, he must confess, seems at variance with his observations of tendon physiology.

When both peroneal muscles are present, they can be converted into such powerful dorsiflexors that the posterior bone block is not necessary. Some operators, notably Freiberg, transplant only the peroneus longus. Although this muscle can unquestionably produce dorsiflexion, the balance of power would remain strongly in favor of the plantar flexors. A muscle balance more nearly comparable with the normal can be secured only by utilizing both peronei. This will subtract from their everting power and a varus would result were the tendon transplants not supplemented by an arthrodesis of the subastragalar joint. A particularly instructive case in this respect was a traumatic drop foot which the author operated on in 1920. The patient, a child of five years, was run over by a reaping machine which severed all the dorsiflexors. Infection followed with extensive destruction of the tendons. Since the muscles themselves were undamaged, the dorsal tendons were reconstructed by means of three free tendon grafts. For this purpose, the peroneus longus tendon was sacrificed. Excellent dorsiflexion resulted, but a year after the operation a mild varus developed, evidently due to the muscle imbalance caused by the loss of the peroneus longus. If the subastragalar joint had been arthrodesed, this deformity would probably not have occurred.

In reaching a conclusion as to the operative indication for transplantation of both peronei, a number of factors must be considered. The first of these is the accurate determination of the muscle strength of the two peronei. The Lovett spring-balance test will tell us a great deal about the everting strength of the muscles, but it does not differentiate between the peroneus longus and the peroneus brevis. Electrical stimulation of each muscle will give some information, but the writer has learned to rely chiefly on palpation of the muscle bellies during the act of contraction against resistance. By far the best operative results are secured when both muscles can be felt to contract powerfully. Unless this action is sufficiently strong to overcome a resistance of several pounds, the author does not favor the transplantation.

The second factor is the age of the patient. Until 1921, it was the writer's rule to operate as soon as the patient was old enough to cooperate intelligently in the after-treatment. After Hoke published his stabilization operation in 1921, and after this operation had been made an integral part of the therapeutic program, the author did not operate until the roentgenogram showed advanced bone development of the tarsus, usually at about the tenth year. Since 1932, following Milgram's observation in Steindler's Clinic, the writer has again operated at an earlier age and some of the most gratifying results in his series have been in children as young as six years.

In operating on these younger individuals, it is important that additional bone be taken from the tibia, so as to fill out the space between the tarsal bones after the removal of the cartilage, and that minimal resections be performed to avoid undue growth disturbance.

The third factor to be considered in the operative indications is the length of time which has elapsed since the acute onset of the poliomyelitis. According to an old rule, at least two years should elapse before any operative treatment is undertaken. Although in general this rule should not be discarded, it must be subjected to frequent exception. The author has seen cases in which the operation was indicated even a year after the onset of the paralysis. These were instances in which very effective treatment had been given during the entire period without the least return of power in the dorsiflexors and with increasing equinus deformity, due to the marked imbalance between the dorsiflexors and the plantar flexors. On the other hand, the writer has seen cases in which the operation was advised against, although five or six years had elapsed, because there was no record of thorough treatment. If even a faint trace of strength is discernible in the dorsiflexors, irrespective of the length of time since the acute onset of the disease, the foot should be immobilized in a position of maximum dorsiflexion, and the weakened dorsiflexors should be given electrical stimulation through a window cut in the plaster. In a surprisingly large percentage of cases this method of treatment has successfully brought a return of strength in the dorsiflexors, thus rendering the operation unnecessary. It is only when thorough postural treatment, combined with expert electrical stimulation and muscle training, has failed that operative correction is indicated. Therefore, the exact length of time elapsing between the onset of the disease and the date of the operation is of much less significance than the nature of the treatment which the patient has received. In no case, however, has the writer operated until at least one year of efficient treatment has been given.

In describing the operative technique, it is unnecessary to repeat all the details, since these have been given in numerous other publications. Certain points should, however, be emphasized. The stabilization of the tarsal bones should always be done before the tendon transplantation. For a number of years the author performed the bone operation several weeks before the tendon operation, allowing the first operative wound to

heal completely before doing the second step. In recent years, with increasing experience, he has been able to combine the two operations into one, but he always follows the rule of doing the bone work first. This permits complete correction of the deformity and enables the operator to gage the tension of the tendon more satisfactorily. The second point is the question of lengthening the Achilles tendon. This, like the tendon transplantation, should not be attempted until the bone operation has been completed, for in many instances the Achilles tendon, which at the time of examination seemed decidedly too short, will be found approximately the right length after the stabilization has been completed. However, if adequate dorsiflexion is not possible, the Achilles tendon should be lengthened sufficiently to permit dorsiflexion to 90 degrees. Of the numerous methods which are possible, the writer prefers the hemidivision of the tendon in different horizontal planes,—the middle section cutting the deep surface of the tendon and the upper and lower sections cutting its superficial half. The operation can be done subcutaneously as well as by the open method.

When the tendons are transplanted, the peroneus longus is run through a subfascial course to the upper pole of the sheath of the tibialis anterior, then downward through the sheath to the insertion of the tendon of the tibialis anterior. To facilitate its course, a guide suture is passed through the sheath and then upward from the pole of the sheath across to the anterior intermuscular septum. The line of this guide suture must be a straight one and must be such that, were the silk fastened to the insertion of the tibialis anterior, a strong dorsiflexion and inversion of the foot would occur. By running the tendon through the sheath of the tibialis anterior, it is possible to conserve the normal gliding mechanism of the paralyzed tendon and to utilize it for the transplanted tendon.

For the peroneus brevis the intrasheath course is not advisable, since, if the tendon were drawn through the sheath of the extensor digitorum longus, it would have to run a zig-zag course which would greatly interfere with its free gliding. It is, therefore, wiser to run the peroneus brevis through the subcutaneous fatty tissues. It is attached directly to the bone by drilling a hole through the fourth metatarsal at its proximal extremity. The drill passes through the bone to the plantar surface of the foot; a small nick is made in the skin and, through this channel, the tendon is drawn by means of a chromic suture threaded on a long, straight needle. This needle is then reinserted into the plantar wound and made to appear on the lateral aspect of the foot near the lower extremity of the original incision. The chromic suture may then be fastened securely on the dorsum of the foot, thus avoiding any knot in the more sensitive plantar region.

To facilitate the passage of the peroneus longus from the lateral compartment of the muscle to the anterior, the author still follows the original method of everting the deep surface of the fascia of the lateral and anterior compartments. These deep surfaces are coated with paratenon,

or gliding tissue, and, when united by a very fine silk stitch, they form a perfect physiological bridge over which the peroneus longus tendon can glide from its original situation into the anterior compartment of the muscle. The execution of this step of the operation requires about four minutes and is, in the writer's opinion, thoroughly justified by the results.

Some operators use a subcutaneous pathway for both tendons. Frequently they get good gliding of the transplanted tendon if their technique is sufficiently atraumatic. They lose, however, the leverage action and controlled angle of application of force afforded by the annular ligament of the ankle and the advantage afforded by the normal gliding mechanism of the sheath of the tibialis anterior.

In determining the tension under which to fasten the tendons, the operator should be guided by the physiological fact that, when the foot is held in such a position as to approximate the origin of the muscle and its new insertion, the tendon should run in a straight line without any tension whatever. The operator, therefore, need only pull on the transplanted tendon with sufficient strength to make its course a straight one. Excessive tension is bad for the muscle fibers, since it subjects them to undue strain. Less tension than the normal is also bad because the tendon is then slack and the muscle belly shortens, with corresponding loss of power.

The author's experience in the after-treatment of these cases has been most instructive. Originally it was feared that a lengthy period of immobilization would cause adhesions to develop in the course of the transplanted tendon and, therefore, mobilization for three weeks after the operation was advocated. This invariably caused excellent gliding of the transplanted tendon, but, in a number of instances, resulted in displacement of the tarsal bones. For this reason the period of immobilization was prolonged and, to the writer's surprise, he discovered that a foot could be kept immobilized for six or eight weeks without the development of adhesions to the tendons which had been operated upon. At the present time, the routine is to change the original plaster-of-Paris three weeks after the operation and then to apply a second cast which is left on for four or five weeks, depending upon the age of the patient. In the second plaster a window is cut over the transplanted peronei, so that electrical stimulation of these muscles may be begun four weeks after the date of the operation.

When the plaster is removed, a light brace is applied with a catch to prevent drop-foot. The patient is given exercises and electrical stimulation to the transplanted peronei.

Despite the fact that, at the joint meeting of the British and the American Orthopaedic Associations in 1929, a prominent English surgeon stated he never had seen a transplanted tendon perform an action physiologically opposed to its original function, the author's patients have, without exception, learned to use their peronei as dorsiflexors. In fact, the action of the transplanted tendons was in one case so powerful that it

produced a calcaneus deformity. This overcorrection of the original deformity was probably due to excessive lengthening of the Achilles tendon, as it was promptly cured by reefing the elongated tendon. It emphasizes the powerful dorsiflexor action of the transplanted peronei and the necessity for accurate preoperative tests of muscle strength.

In three instances in his series of peroneal transplants, the writer has had occasion to perform secondary operations to correct minor abnormalities of the foot, such as hallux valgus. At the time of these secondary operations permission was given by the patients to inspect the transplanted peroneus longus tendon through a small incision. In all three cases the attachment of the tendon to the bone so closely resembled that of a normal tendon that it could not be distinguished from the normal. In one case the author was allowed to remove a small specimen of tendon with the bone to which it was attached. When examined microscopically, this showed a transition of tendon to bone, corresponding exactly with the normal. When the muscle was stimulated electrically, within the sheath of the tibialis anterior the peroneal tendon could be seen to glide to and fro with approximately normal range of motion. The peroneal tendon had apparently fused within the sheath with the tibialis anterior, for only one tendon was distinctly visible. There were no adhesions between the tendon and the lining wall of the sheath.

SUMMARY

Twenty years of experience in the treatment of paralytic drop-foot by means of the physiological tendon transplantation, combined with stabilization of the ankle, have convinced the author of the efficacy of this method in the correction of this type of paralytic deformity. The actual examination of the tendons at secondary operations, as well as by clinical tests, shows that transplanted tendons can function with almost the same strength and freedom of motion as normal tendons, provided that the physiological method of transplantation is followed.

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TUBERCULOUS PERICHONDRITIS AND PERIOSTITIS OF THE RIBS

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During the past fifteen years of experience with more than fifty cases of chondromyelitis of a typhoid and paratyphoid character, cases of tuberculous perichondritis were not infrequently met with, and, from 1921 to 1933, fourteen cases in which the diagnosis was definitely determined came under observation. Of this number, ten were treated surgically and four conservatively. The ten cases were operated on in different stages of the disease, and, by examination of the resected cartilage and ribs, it was possible to observe the different stages of the pathological process and, with a reasonable degree of certainty, to draw conclusions as to the undetermined question of whether cartilage with its perichondrium and the rib with its periosteum become involved primarily, or whether the tuberculous focus appears in the surrounding soft tissues and the rib becomes involved secondarily. Some authors hold the opinion that lesions in the cartilage have their origin in the perichondrium; others (Hayem, Lediberder, Lannelongue, Poloson, Alglave, Sorrel, and Mouchet) have observed cases of primary tuberculous chondritis. Dujarier observed in a sixteen-year-old girl an abscess of the chest which he considered unquestionably to be of cartilaginous origin.

However, many modern authors who are interested in the subject of surgical tuberculosis incline to the view that the cartilage and the rib become involved secondarily. Kisch considers primary infection of the cartilage doubtful inasmuch as tuberculous infection is originally embolic, whereas the "hyaline cartilage, at any rate in youth, does not have vessels". The opinion that blood vessels are absent in the rib cartilage cannot be substantiated at the present time, especially since the works of Russian authors (Linberg, Petrov) in connection with typhoid chondritis.

In the histological examination of rib cartilage in young individuals who had died from various causes, carried out in the laboratory of Prof. Yelenevski, the author was able to demonstrate that in youthful subjects not only are blood vessels present, but also elements of the so called cartilage marrow are copiously vascularized. It, therefore, follows that, although the blood vessels may be absent, this cannot be used as an argument against primary chondritis. The typhoid and paratyphoid lesions demonstrated during operation and on pathological preparations that the cartilage is primarily affected, and that the vessels, together with the cartilage marrow, have a very definite significance.

In the case of tuberculous infection it would seem that the relative significance lies not in the vascularization, but in other factors which

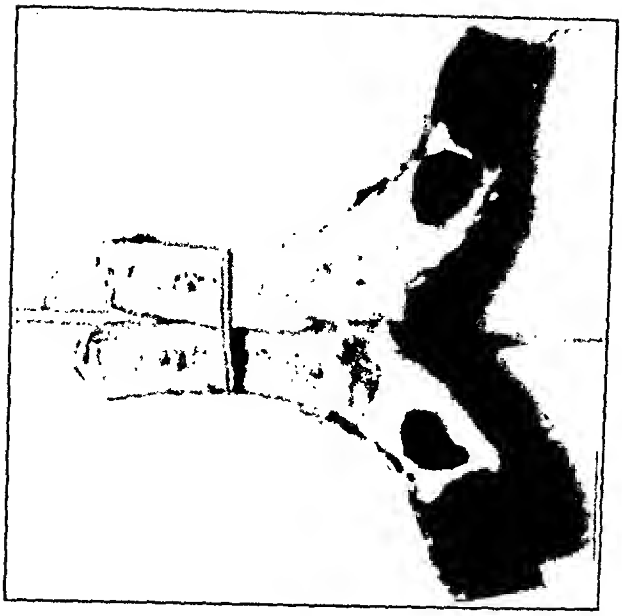

FIG. 1
Specimen showing paratyphoid chondritis. Intracartilaginous abscess on the line of demarcation between bone and cartilage.

will be discussed. Recently Iselin has given his opinion that cold abscesses of the thoracic wall are usually the result of tuberculous pleurisy, of tuberculosis of the lungs, or of tuberculosis of the mediastinal lymphatic glands. Although this does not solve the question of the primary localization of the tuberculous focus, it does endorse the observation which the author has made during operations and also the opinion of Pereshivkin that the suppuration of the peripleuritic glands is an etiological factor in peripleurisy.

In a series of operations for tuberculous perichondritis, and in more than forty cases of infectious chondritis, there was noted a significant difference in the pathological anatomical changes of the cartilages in the two processes. In infectious chondritis there was nearly always found a cavity in communication with the surface by either a large or a small opening, and in one case of an early resection there was found a cystic focus in close proximity to the line of demarcation between the opening and the cartilage. (See Figures 1 and 2.) This is significant with respect to the influence of primary lesions of the cartilage in infectious chondritis. This localization of the focus tallies with the localization in cases of osteomyelitis.

In cases of tuberculous lesions of the cartilage of the rib, the cavities in the cartilage or in the rib were not found; on the other hand, the lesion was a surface ulcer of greater or of lesser extent. (See Figures 3 and 4.) Frequently there was found a cavity of appreciable size located beside the pleura and under a slight lesion of the cartilage or of the rib, and the changes in the adjacent soft tissues were always more noticeable than in the rib or in the cartilage.

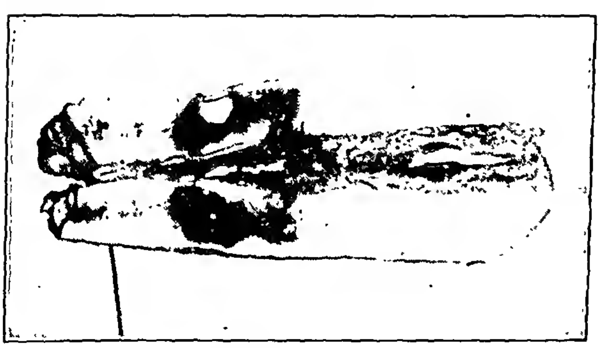

FIG. 2
Specimen showing paratyphoid chondritis. Intracartilaginous abscess on a lesion of the cartilage.

The absence of isolated rib lesions, the limitation of the destruction in nearly all cases to the pleural surface of the cartilage, and the discrepancy between the appreciable peripleural abscess and the slight

lesion of the cartilage led the writer to believe that in many cases there existed a lesion of the lymphatic glands, following which secondary changes appeared on the surface of the cartilage. This opinion is to a very significant degree supported by the following case of an early rib lesion.

CASE 1. K. A., aged twenty-four, on March 29, 1923, presented a swelling in the region of the left fifth, sixth, and seventh ribs between the mammillary and midaxillary lines. This swelling was irregular in outline, immovable, and not sensitive, and there were no cutaneous changes. The temperature was normal. No abnormality of the internal organs was found. Widal tests were negative for typhus, paratyphus *A*, and paratyphus *B*. The Wassermann and Sachs-Georgi tests were also negative.

At operation on April 5, 1923, through a curved incision, the muscles were found to be infiltrated. A fistula was revealed on the lower border of the seventh rib, and resection of the sixth and seventh ribs disclosed a peripleuritic cavity filled with caseous and disintegrated material. On the inner surface of the fifth rib there was slight necrosis of the tissues, and above the inner side were found small lymphatic glands showing caseous degeneration. The cavity was thoroughly cleaned, its walls were swabbed with iodine, and the cavity was closed. Healing was by primary union. Observations in 1925 showed a thick scar adherent in one portion to the deeper structures. Recovery had taken place rapidly.

FIG. 3
Roentgenogram showing tuberculous perichondritis.

This case endorses the opinion that in most cases the rib and the cartilage are affected secondarily, and that specific changes in lymphatic vessels and glands are responsible for the invasion of the surrounding tissues. In confirmation of this is the interesting fact that the radiocarpal joints of children under four never become tuberculous, for the reason that up to this age the joint remains entirely cartilaginous. The anatomical fact that the tuberculous abscesses of the thoracic wall are frequently located in the linea parasternalis or in the linea scapularis posterior also substantiates this opinion. The intercostal vessels, opening into the thoracic duct, are interrupted by the

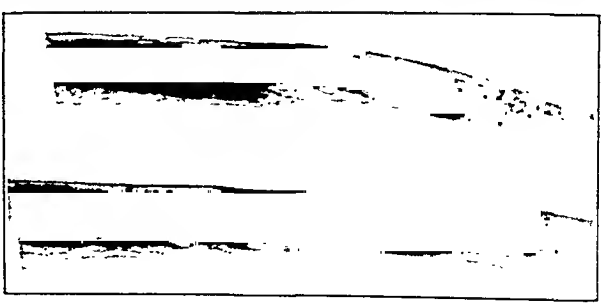

FIG. 4
Roentgenogram showing tuberculous periostitis of the rib.

intercostal glands which lie at the level of the rib ends. The anterior intercostal vessels are interrupted by the anterior mediastinal glands at the point of union between the costal cartilages and the sternum. These glands interrupt also the passage of the internal mammary lymphatics.

In a case of resection of the third cartilage, in connection with an abscess on the side of the chest, there were no great changes found in the cartilage. The abscess led to the under side of the sternum, which was partly resected: on the posterior surface, very slight changes were observed. The tuberculous character of the lesion was proved and recovery took place rapidly.

The anatomy of the lymphatic system and the pathological changes which are located in definite places endorse the opinion that primarily the glands adjacent to the pleura are the first to become infected, following which perichondritis or tuberculous periostitis occurs, from which develop the cartilaginous or bony lesions in proximity to the abscess. It is probable that the extension of the tuberculous focus occurs through the lymphatic rather than through the vascular system.

It is characteristic of tuberculous perichondritis that the development is insidious and without definite cause. There may be observed a slight thickening of the cartilage of the breast, or an abscess may appear in the bone cartilage. A limited amount of thickening of the cartilage, if of a tuberculous character, indicates that the process is localized and adjacent to the pleura, but has not yet extended to the surface of the cartilage. If the abscess has already developed, tenderness over the area of the cartilage increases. The abscess may gravitate downward behind the rib or cartilage and appear at a point distal to the original focus, which makes more difficult the localization of the point of origin.

Occasionally a cold abscess arises from the osseous-cartilage border and gravitates under the ribs, simulating perichondritis. Rarely does an abscess gravitate inward into the mediastinum or into the pleural cavity, and such an abscess was not observed in the author's series of cases.

With lesions of the cartilage, however, abscesses nearly always localize themselves in close relation to the infected rib and do not gravitate. They do not in any way differ from cold abscesses of bone tuberculosis in general. Abscesses may, however, be found in different parts of the thorax. In two cases spondylitis and tuberculous perichondritis were observed simultaneously. There is apparently no constant relation between the infection of the cartilage and the infection of the lungs or of the pleura. (A history of pleurisy was established in three cases.)

During a typhoid epidemic, in a few patients there developed a swelling in the region of the cartilage of the ribs, which, in some of the cases, proved at operation to be tuberculous perichondritis. Diagnostic difficulties may be appreciated from the statement that in three of these cases the diagnosis had been typhoid chondritis.

The clinical picture, the bacterioserological data, and experiments on animals have yielded definite information for differential diagnosis.

Tuberculous abscesses on the anterior chest wall attain to larger size than those of typhus or of paratyphus origin, and develop slowly without noticeable changes in the skin.

Typhoid chondritis is more frequently seen in the cartilages of the sixth and seventh ribs, probably due to the early vascularization and ossification of these cartilages. Tuberculous chondritis may occur in any cartilage and often is found above the sixth rib. In tuberculous perichondritis the general condition is more serious and is accompanied by a loss of weight and subfebrile body temperature. In typhoid chondritis the course of the disease is prolonged and the roentgenogram shows early ossification around the inflammatory focus. In tuberculous perichondritis slight evidence of ossification appears only late in the disease. If periostitis or perichondritis occurs with the tuberculous process in other locations, the prognosis is unfavorable.

In regard to the treatment of these conditions, observers differ. Some recommend radical operation with resection of the rib and closure [8]; others consider it insufficient to puncture or to inject the area and state that it is necessary to remove the focus as far as possible within healthy limits without opening into it, and that the cartilage must be removed [6,7]. Still others recommend puncture or injection of different solutions; x-ray therapy for tuberculosis has always received considerable attention.

From 1921 to 1933, ten cases of tuberculosis of the ribs and cartilages were operated upon.

In the case of tuberculous lesions of the cartilage of the rib, radical resection of the cartilage is employed [3]. The bony process is resected as early as possible, re-

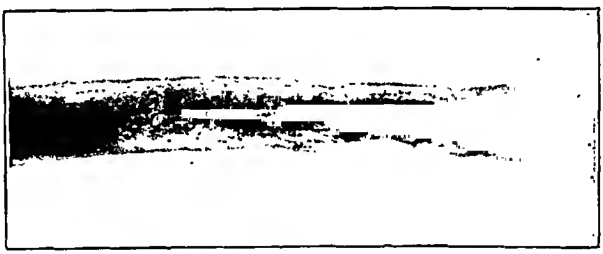

Fig. 5-A
Roentgenogram showing tuberculosis of the rib.

Fig. 5-B
Specimen showing tuberculosis of the rib. Same case as in Fig. 5-A.

gardless of the localization of the focus which does not require opening. The anterior perichondrium, with the cartilage, is removed; the posterior perichondrium, in the form of a band, remains on the pleura. At the intercostal articulations the diseased cartilage is removed without injuring the area of the sound cartilage. By this means, there is left at the fifth cartilage, above the articulation of the sixth and seventh cartilages, a stump deeply hidden under the perichondrium. The wound is closed without tension on the skin.

TABLE I

TREATMENT AND END RESULTS OF FOURTEEN CASES OF TUBERCULOUS PERICHONDRITIS

Procedure	Healed	Fistula	Death	Total
Radical resection of the cartilages	5	2	1	8
Opening of abscesses	1	1	0	2
Conservative treatment	2	2	0	4
Total	8	5	1	14

Radical operation is to be performed only in the early stages of the disease when the thickening of the ribs or of the cartilage is slight. After this period, and if an abscess has formed, the conservative treatment is advisable. If a fistula is present, and if the patient is in good condition, a radical operation may be indicated; in this case, however, it is necessary to determine exactly the primary source of infection. Before operation, it is advisable for therapeutic reasons to inject from five to eight cubic centimeters of Calot's emulsion.

Of the ten patients in the author's series, eight were operated upon by the radical method. Primary union was obtained in three of the early cases. In two cases the fistula remained and did not heal during seven months of observation. In one case of miliary tuberculosis, operated upon in the abscess stage, death followed in one and one-half months after operation. In this case operation was not advisable. In only two cases were the abscesses opened and in each of these the origin of the abscess was not found and resection of the ribs was not performed. In one case there was recovery with heliotherapy; in another, a fistula remained. If a fistula remains after operation, it is wise to carry out systematic treatment of injection with Calot's emulsion.

We may thus state that operative treatment gives the most satisfactory results in the early stages of the disease. The operation must be radical and the wound closed. Conservative treatment in perichondritis and periostitis is more adapted to the stage of abscesses and fistulae. General treatment by heliotherapy, diet, etc., is always indicated. Calot's emulsion has proved effective in treating abscesses and fistulae.

From a study of the cases the following observations have been made:

1. The rib cartilages in the majority of cases become secondarily

infected and are the medium through which the disease extends from the adjacent peripleural lymphatic vessels or glands.

2. As opposed to typhoid chondromyelitis (chondritis) in which the cartilage and marrow become primarily affected and destruction proceeds from the center to the periphery, in tuberculous perichondritis the destruction begins almost always in the periphery and extends to the deep-lying parts of the cartilage.

3. Operative treatment of tuberculous ribs and cartilages gives the most favorable results up to the time of the formation of the abscess. Curettage and partial resection are irrational. Operation must consist of the radical removal of the entire cartilage. Thorough evacuation of the caseous material in the cavity is followed by closure. In lesions of the bony portion of the rib it is possible to limit the resection, thus avoiding injury to the cartilage.

4. In the abscess and fistula stage, conservative treatment is indicated. Consistently good results have been obtained from the systematic injection of Calot's emulsion.

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TUMORS OF THE PELVIC GIRDLE

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Tumors of the pelvic girdle present a diagnostic and therapeutic problem which has been all but ignored. Forty-one cases admitted to two hospitals during a five-year period suggest that they are by no means rare. These cases did not include instances where pelvic-bone involvement represented merely the terminal phase of a generalized metastasis, but were chosen because the tumors were an important part of the clinical picture. Of the forty-one cases included in this series, twenty-one or about 50 per cent. were primary tumors. The remainder were metastatic. This is a much higher percentage of primary neoplasms than is ordinarily suspected to occur in the pelvic girdle. The primary tumors were classified as follows:

	Cases
Osteochondroma	4
Osteogenic sarcoma	5
Fibrosarcoma	5
Ewing's myeloma	4
Lymphosarcoma	1
Undiagnosed	2
Total	21

Of the metastatic tumors, seventeen were carcinomata, one was a myosarcoma (primary in the uterus), and two were hypernephromata. All but four of the tumors were malignant. Five fibroblastic sarcomata and one lymphosarcoma were soft-tissue tumors invading the pelvic bones from adjacent soft tissues.

It may be said that in general the presenting clinical picture was that of a tumor of the pelvic bones, and, except for the rapidity of development or of fatality, the symptoms were not influenced by the pathology of the neoplasm. Tumor of the pelvic girdle can be suspected at any age, although it is more frequently found during the third, fourth, and fifth decades. The youngest specimen in our series was an osteogenic sarcoma of the ilium in a child of eleven. The oldest was a metastatic carcinoma of the ischium in a man of seventy-four. Sex plays no part in the differential diagnosis.

In thirty-seven of the forty-one cases (all but four) the presenting symptom was pain. In twenty-four cases the pain involved the extremity and was described either as radiating down from the buttock, or as preceding any local pain at the pelvic girdle. Although each case varied somewhat in the detail of onset and in its time relationship to pain at the

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hip or the buttock, the important generalization can be made that the presenting complaint was such as to suggest some form of the so called sciatic syndrome, lumbar radiculitis, or sacro-iliac syndrome. In thirteen cases the pain was referred to the lumbar spine, lumbosacral region, or sacrum, presenting the clinical picture of "low-back pain". In several of these cases, radiation down an extremity followed some time after the onset of back pain. In almost every instance, the reflexes and other gross neurological manifestations were recorded. These were of little help. In young cases they were negative except in advanced stages where peripheral nerve involvement occurred. In the older cases they represented the possible findings of root pressure or unrelated spondylitis or radiculitis. In two cases—one a female of thirty with an extensive osteochondroma of the ilium, the other a female of sixty-one with a fibrosarcoma attached to the pelvic bone—swelling or tumor was the presenting complaint. Pain was either absent or negligible.

In ten cases there was a history of injury. This varied from a fall on the buttock to a fractured hip. The story of strained back was given in five of the cases. These histories were important in that they directed the examiner's attention away from the possibility of neoplasm. Seven of the patients in the series had been treated for weeks or for months by physiotherapy or by manipulations. Among the carcinomata several were of particular interest. In eleven out of seventeen of these cases no symptoms of visceral carcinomata were previously complained of. Pain in the legs or lower back was the presenting complaint of patients subsequently discovered to be suffering from carcinoma. In eight of these, the site of the primary neoplasm was never discovered.

The duration of symptoms varied from eight weeks to two years, with few exceptions. The symptoms in two of the cases of osteochondroma had lasted for eight years, appearing recurrently; in one of the cases of metastatic carcinoma the duration was five days. Most patients described symptoms of from three to six months' duration. Out of this general clinical picture, however, one symptom was prominent. In nine of the cases, some time after the onset of pain (from several weeks to several months), the patients complained of "weakness" in the affected extremities. This weakness was a motor disability, even though definite motor paralysis could seldom be distinguished. It led often to an early exaggerated limp not associated with the severity of the pain.

In this brief report we wish to call attention to several specific observations:

1. Tumors of the pelvic girdle are not rare. Half of them are primary tumors if one excludes cases in which pelvic involvement is merely the terminal phase of a generalized metastasis.

2. They are most liable to present the clinical picture of an atypical sciatic or sacro-iliac syndrome, or that of "low-back pain".

3. Motor disability of a non-specific character in an extremity during the course of a sciatic or sacro-iliac syndrome calls for a roentgeno-

graphic study of the pelvis even though previous roentgenograms have been negative.

4. A consideration of pelvic-girdle tumor must enter into every routine examination of the patient with "low-back", "sacro-iliac", or "sciatic" symptoms.

The relationship between the location of the tumor and the area of radiating pain is an interesting side-light on the sciatic problem. Of twenty-five patients in whom the nature of the pain radiating into an extremity was in a broad sense of the sciatic type—that is, following the posterior aspect of the thigh, the calf muscles, the ankle, or any combination of these—the tumors were found in the following locations:

Region	*Cases*
Sacro-iliac	6
Alae of ilium (not at sacro-iliac joint)	10
Acetabulum	3
Lower ilium and trochanter	1
Ischium	1
Pelvic bones (multiple foci)	2
Sacrum (not at sacro-iliac joint)	2

This distribution tends to confirm the observation that the sciatic or sacro-iliac syndrome may be due to any factor which disturbs the muscular mechanics about the gluteal or iliac region, and is not specifically related to affections of the sacro-iliac joint, the sciatic nerve, or any definite muscle.

One further fact must be noted. A negative roentgenographic report relates only to the absence of abnormal shadows at a given time. In several of our cases, roentgenograms had been reported negative up to within six weeks of admission. In a protracted case of this kind, a single negative roentgenographic finding must not preclude reexamination.

FASCIAL TRANSPLANTS IN PARALYTIC AND OTHER CONDITIONS *

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The prevention and correction of deformities of the spine and the trunk, which develop so rapidly and extensively in the course of infantile paralysis, have always presented great difficulties. Muscle training, supports, and stabilizing operations on the spine have all been helpful, but have left much to be desired when the final results of treatment were evaluated. Lowman in 1932 and Mayer in 1936 reported several cases in which the action, or at least the stabilizing effect, of abdominal muscles was recaptured to some extent by the use of fascial strips, sutured to healthy muscles and passing over to be attached at the insertion of the weak or paralyzed muscles, or passing from bony point to bony point. The results reported were sufficiently satisfactory to challenge attention and the method seemed to be a distinct step forward in the management of paralytic deformities of the spine and the trunk.

Impressed with the possibilities which these observations suggested, we checked over our old cases as the opportunity presented and began making more careful examinations of all of our new cases with respect to weakness or paralysis of the muscles of the abdomen, the chest, and the spine, and to the effect of such weakness upon stability of the pelvis and the trunk, and upon the effectiveness of the muscles of the extremities. Our observations led us to about the same conclusions that Lowman had arrived at with regard to the important part played by weakness or paralysis of these muscles in the production of distortion and instability of the trunk and the pelvis and of interference with the functioning of the muscles of the extremities because of this loss of stability. Accordingly, we began to carry out the procedure suggested by Lowman for recapturing the power of weak or paralyzed muscles of the abdomen, the spine, and the chest. While seldom spectacular, the results seemed decidedly worth while, and we have continued to follow this procedure as the occasion arose. The object of this report is not, however, to present a mass of material with definite conclusions based upon a number of results, but, rather, to offer our experience in a few cases as a suggestion for future exploration in what seems to be a very promising field.

In our experience the greatest difficulty encountered in using fascial transplants has been in determining what muscles or groups of muscles are chiefly at fault. Lowman and Mayer have indicated useful tests which have been helpful, but there is yet much charting to be done before even an approximately sure course can be steered. The determination of weakness in the upper and the lower recti and the abdominal obliques is

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FIG. 1

Fascial transplant to replace the paralyzed quadratus lumborum.

not difficult, since Beevor's sign, or shifting of the umbilicus upward, downward, or to one side or the other when the head is raised against light resistance, and loss of muscle tone are fairly accurate guides. The determination of weakness in other muscles—the quadratus lumborum, the latissimus dorsi, the serratus anterior, the rhomboidei, and, at times, the trapezius—is not so readily made and requires much study, and then one is not always sure. In our experience, the reason for this lies in the difficulty of isolating the action of these muscles because of their intricate and complex relationship in function with each other and with other muscle groups. However, it has seemed from our examinations that weakness in all of the muscles mentioned has been a factor in the production of deformity or of interference with function in some cases, and, when feasible, an effort has been made to replace their lost action or to recapture as far as possible their stabilizing influence by attaching fascial transplants from unparalyzed muscles to a fixed bony point.

It seems unnecessary to discuss plastic repair of the abdominal muscles, since this ground has already been most carefully and exhaustively discussed by Lowman and Mayer, and this phase will, therefore, be but briefly touched upon. There are, however, certain fascial transplants about the shoulder which have seemed helpful from our experience with them, and it is these which we wish to discuss in more detail.

Our experience with abdominal plastic repair is based on forty-four cases with the following distribution: superior rectus, one case; inferior rectus, eleven cases; upper oblique, seven; lower oblique, twenty-six; quadratus lumborum, eight (Fig. 1); and various combinations of these. In these cases the benefits which have been derived may be catalogued as follows: (1) improvement in general health; (2) greater endurance, as determined by ability to walk greater distances and to get about more extensively with less fatigue; (3) ability to lift the foot from the ground and to take steps when this has been impossible before operation; (4) ability to go up steps; and (5) in two cases ability to walk without brace or support when formerly both were necessary. Unfortunately, we have had no opportunity to test the value of the procedure in preventing the occurrence of spinal deformities, as we have seen no early cases of infantile paralysis since we have been carrying out these transplantation operations.

Fascial transplants about the shoulder, for the purpose of stabilizing the scapula and thus preventing or minimizing deformity of the chest and the cervical region and improving the function of the muscles of the upper extremity, have, we feel, proved useful in two types of cases:

(1) Paralytic scoliosis with drop shoulder and marked cervical curvature;

(2) Paralysis of the scapular muscles with asymmetry of the shoulder, deficient stability of the shoulder girdle, and developing high thoracic curve.

PARALYTIC SCOLIOSIS WITH CERVICAL CURVATURE

The cases included in this group are those in which, because of weakness or paralysis of the spinal and the scapular elevator muscles, there occurs a descent of the shoulder on one side, and a high cervicothoracic curvature develops. (See Figure 2.) This type of spinal deformity has in our experience been very difficult to prevent and most resistant toward all efforts directed against its tendency to become progressively worse. Confronted with a problem, no solution of which has ever been entirely acceptable, it was thought that any procedure which would elevate the dropped shoulder and hold it in that position should help to some extent in relieving the distortion of the upper trunk and neck and would be worthy of trial even if other deformities of a serious degree were present below this level. Accordingly, it was decided to use fascial strips for this purpose. The objective was twofold: (1) to elevate the dropped shoulder, and (2) to provide a fixator action against the pull of the unparalyzed muscles on the convex side of the cervical curve, which is concave toward the side of the depressed shoulder. To accomplish these two objectives, two fascial strips were used,—one was passed from the spine of the scapula to the cervical muscles on the concave side of the cervical curve, and the second was passed from the spine of the scapula to the spinous process of the first thoracic vertebra. (See Figure 3.)

Fig. 2

Dropping of the right shoulder and high cervical curve with increasing deformity. This is the type of case considered suitable for operation.

The procedure was carried out as follows: Through an appropriate incision, the spine of the scapula was exposed well outward toward its acromial end, and a slot was made through the spine. An incision exposing the cervical fascia was then made, extending from the spine of the scapula to the apex of the cervical curve on its concave side. Next, a strip of fascia lata, which by suturing the edges with fine catgut had been converted into a tube with the gliding surface out, was laced into the cervical muscles at the apex of the curve on the concave side. The depressed shoulder was then elevated as much as possible, and the fascial tube was passed through the slot in the spine of the scapula and fastened with silk. An incision was then made over the spinous process of the first thoracic vertebra, and a hole was drilled through the spine at its base. A fascial strip, looped through a second slot made at the vertebral end of the spine of the scapula, was passed through a subcutaneous tunnel to the spine of the first thoracic vertebra, drawn through the hole, and sutured under tension. The incisions were closed in layers and a plaster cast was applied with the arm in abduction of from 40 to 50 degrees, or the shoulder was attached to the head of the bed. At the end of three weeks exercises were begun, and at the end of from five to six weeks all support was removed.

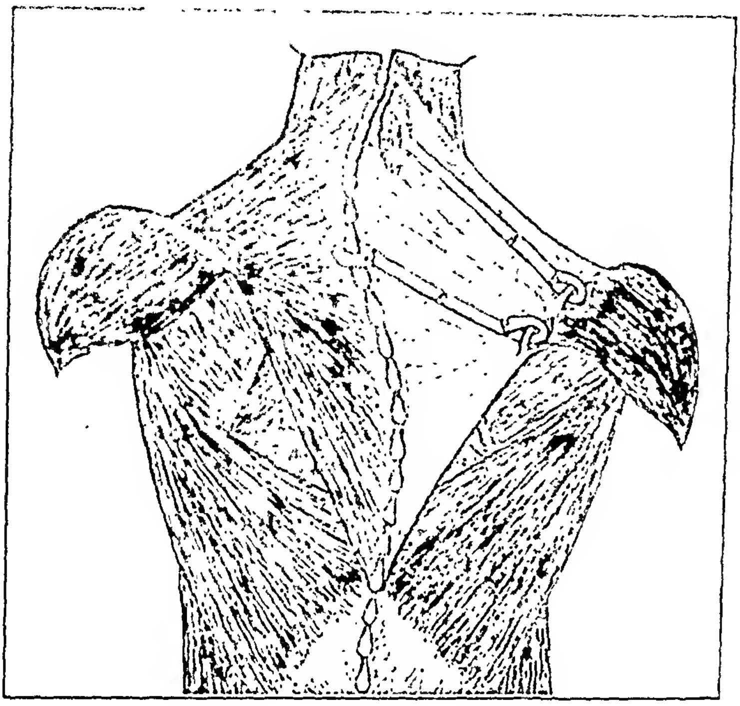

FIG. 3

A: Fascial strip running from the spine of the scapula to the cervical muscles. *B:* Fascial strip running from the spine of the scapula to the spinous process of the first thoracic vertebra.

It should be mentioned that in these cases the second transplant, running from the vertebral end of the spine of the scapula to a hole drilled in the spinous process of the first thoracic vertebra, was used to give additional support and anchorage, so that the entire strain of supporting the shoulder would not come upon the cervical muscles.

The procedure was carried out in six cases and has proved satisfactory beyond our expectations. In all cases the shoulders have remained elevated to a satisfactory degree and no support has been necessary. In addition, there has been no increase in cervical deformity, and in every case there has been some improvement,—all of these patients report a

definite decrease in neck pain and fatigue and a more comfortable feeling generally since the operation. The most extreme case in which the operation was performed was that of a girl, sixteen years of age, who, although she had previously had a successful stabilization of the lower spine, continued to have dropping of the right shoulder, increasing cervical deformity, and increasing limitation of neck motion with pain which eventually became so disturbing that it was necessary to put the patient in the hospital and to apply head traction. Following operation, the shoulder remained elevated quite satisfactorily without support, the neck pain disappeared, and there was a very satisfactory increase in the range of neck movement. Four of these cases have been observed for three years after operation and two for two years.

Fig. 4

Same patient as in Fig. 2, four weeks after operation. The patient states that there is distinct improvement in the movement of the neck and feeling of comfort. Sufficient time has not elapsed for final result.

PARALYSIS OF THE SCAPULAR MUSCLES

In this group the main difficulty to be overcome was lack of stability of the scapula, due to weakness or paralysis of muscles running from the spine and the trunk to the scapula. Weakness of these muscles resulted in hypermobility of the scapula which prevented effective use of the shoulder joint. There was also a tendency for a high thoracic and even a cervicothoracic curve to develop. It was felt that stabilization of the scapula, by providing a more normal resistance to the action of unparalyzed scapular and thoracic muscles, would have a restraining effect upon the development of spinal deformity and would to some extent improve shoulder-joint function.

In one case there was considerable hypermobility of the scapula, which moved inward toward the vertebral column and rotated downward and inward when the shoulder was abducted, and a high thoracic curve was beginning to develop. There was some atrophy of the rhomboidei and the trapezius. Since it is the serratus anterior which

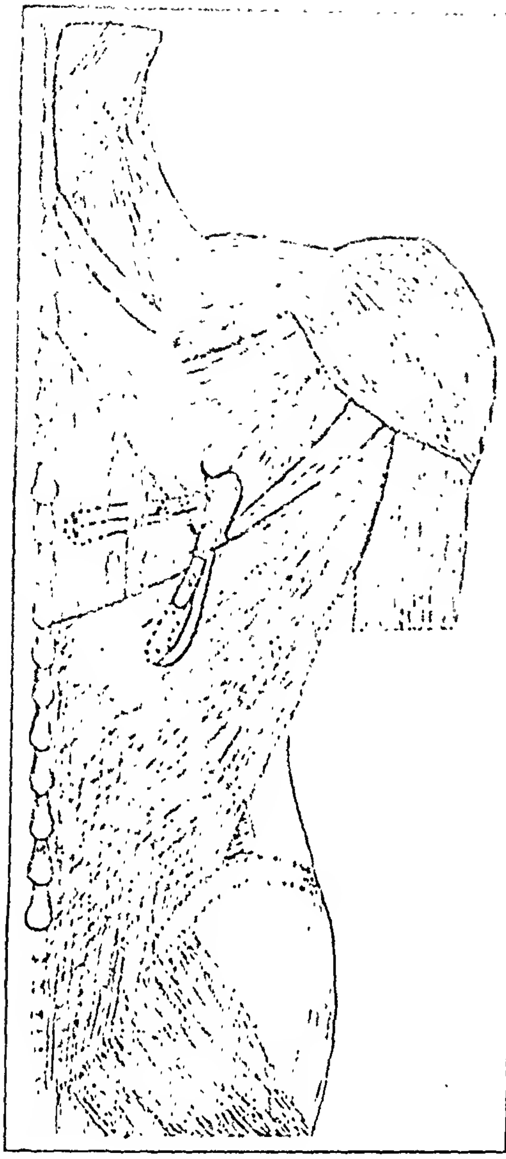

FIG. 5

A: Fascial transplant from the lower vertebral border of the scapula to the spinal muscles. *B:* Fascial transplant from the lower vertebral border to the *latissimus dorsi* muscles.

draws the scapula laterally and keeps it applied to the ribs, this muscle seemed to be the muscle most seriously involved. To replace the action of the paralyzed serratus anterior, a fascial transplant was fastened in a slot made at the lower axillary border of the scapula and passed forward through a subcutaneous channel. The distal end was split and one section was laced into the lower fibers of the pectoralis major and the other into the anterior fibers of the latissimus dorsi; the fixation was made with the scapula drawn forcibly toward the axilla and with the fascial strip under strong tension. The purpose was to prevent the movement of the scapula toward the vertebral column and thus to secure stability. Theoretically it was hoped that the pull on the transplant would provoke a response in the pectoralis major and the latissimus dorsi and give some additional active pull on the scapula. The result of this procedure was a partial anchoring of the scapula which did not move toward the vertebral column so strongly, but remained more or less fixed. However, rotation of the upper border downward and inward was not prevented, and some dropping downward of the shoulder persisted. To overcome this rotation, a second transplant, running from the spine of the scapula to the cervical muscles, was used. This has given added stability and, we believe, has lessened the tendency to dropping of the shoulder. The result in this case is too recent to enable any conclusions to be drawn as to the effect of the procedure upon the course of the cervicothoracic curve. The improvement in shoulder function, however, is definite, and we believe that, to this extent at least, the procedure has been worth while.

In a second case the scapula moved toward the axilla and tilted its upper vertebral border inward and downward with abduction of the shoulder. Such a displacement seemed to be attributable to an overaction or unresisted action of the serratus anterior and weakness of the rhomboidei and the levator scapulae. There was weakness of the shoulder move-

Fig. 6-A

Fig. 6-B

Before operation, showing bulging of the right chest wall, due to lack of resistance to the serratus anterior, caused by paralysis or weakness of the rhomboidei and the levator scapulae. A left high thoracic curve was also present. This had been progressive during two years of observation.

ments in this case and a gradually developing thoracic curve with a definite bulging outward of the rib cage on the involved side (Figs. 6-A and 6-B). Our observation convinced us that the action of the serratus anterior was unresisted, due to the loss of the fixator action of the muscles running from the spine to the scapula, and that, as a result, when shoulder movements were made, the scapula moved toward the axilla instead of re-

Fig. 7-A

Fig. 7-B

Same patient (Figs. 6-A and 6-B) three years after fascial transplant to the scapula, showing no increase, and perhaps some improvement, in the bulging of the chest wall to the right. During this time no support or treatment had been given.

maining more or less fixed. Loss of the resistance of the serratus anterior against the rib cage permitted bulging of the ribs on that side and produced a high thoracic curvature toward that side. Stabilization of the scapula was secured in this case (1) by passing a fascial transplant from a slot in the vertebral border of the scapula inward and slightly downward and lacing the distal end into the spinal muscles and (2) by passing a second strip downward and slightly outward into the latissimus dorsi into which it was implanted in the same manner. (See *Figure 5.*) These transplants anchored the scapula fairly firmly against the chest wall and prevented any lateral movement. The result after three years (Figs. 7-A and 7-B) has been restoration of practically normal use of the shoulder and the arm and no increase in what, during two years of observation, was a progressive lateral deformity of the upper thoracic spine.

It should be stated that in all these shoulder cases weakness of the abdominal recti and obliques was eliminated as a possible source of lack of stability in the shoulder, since Lowman had pointed out that paralysis or weakness of these muscles interferes with stability of the rib cage and consequently with the action of the serratus anterior and other chest muscles.

The technique of the operations carried out was essentially that of Lowman in that one end of each fascial transplant was fastened to an active muscle and the other end was given a bony attachment. While attachment of the fascia from one bony point to another bony point, as advised by Mayer, may have some advantage, it seemed to us to lack the very important feature of the active muscle pull which is possible with a muscle-to-bone attachment. In one feature our technique has differed from that which Lowman used,—all our fascial transplants were made in the form of a tube with the gliding surface out, while Lowman's transplants were made as flat bands. It was our belief that by using the tube form of transplant the possibility of adhesions was minimized and a nearer approach to a true tendon was secured. This seems to have been true, since all of the transplants which have been examined have responded actively when the muscle to which they were attached has been contracted.

COMMENT

It is with some hesitancy that these cases are presented, since there remains much spade work to be done before a really systematic set of transplants can be determined from the point of view of effectiveness. This report must be taken, then, as a preliminary one with only suggestive importance and without definite conclusions. There is as well the thought that perhaps reporting these cases at this time may stimulate a deeper interest in Lowman's pioneer work, which, it would seem, has not been as widely studied and used as it deserves.

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RIB-SPLINTER GRAFT IN SPINAL FUSION FOR VERTEBRAL TUBERCULOSIS*

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During the past few years we have had occasion to induce osteosynthesis of the spine in thirty individuals with tuberculosis of the vertebrae, employing the operative technique described by Henry and Geist and including invasion of the vertebral articulations recommended by Hibbs. The majority of these patients presented complicating visceral tuberculosis (pulmonary, renal, peritoneal), while paravertebral abscesses with and without sinus formation were found in most cases. Practically all of this group, at the time of operation, had been confined to bed for many months because of the complexity of the lesions. In the entire series the operative mortality was zero. However, one very disquieting event did occur in practically every case,—namely, when we began to hammer on the tibia to remove bone chips for the graft, it was found that we could depend upon the development of a state of shock at that point. In some patients the shock was not severe, but in others it required hours of careful attention and the administration of saline, glucose, ephedrine, and morphine to sustain the vital processes.

Because of this one complicating factor, it was considered advisable to seek a new source of bone for the graft. In May 1936, we first employed the rib for this purpose, carrying out our preparation of the graft bed in the same manner as before, but placing the rib graft in the form of splinters. Three cases have been so treated, and, although the postoperative period of observation is relatively short (five, four, and three months), the author feels that a description of the procedure and a report of the results are warranted at this time.

OPERATIVE TECHNIQUE

The patient is placed in a prone position on the operating table and prepared as for any type of fusion operation. The skin sterilization is carried well around on one side to permit the removal of rib segments. We have always used two operating teams,—one to obtain the graft while the other prepares the spinal bed and then places the graft. Other authors recommend preparing the graft bed first and then obtaining the graft, thus allowing some time for hemostasis to take place in the spinal wound which is packed with hot compresses.

The Graft: An incision is made over the ninth or tenth rib from the edge of the erector spinae muscle group laterally for a distance of about

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fifteen or twenty centimeters. Retraction of the wound edges will then allow exposure of the underlying ribs which can be removed subperiosteally by incision and stripping of the periosteum in the same manner as that carried out in the usual thoracoplasty. Segments from alternating ribs, measuring from ten to twelve centimeters in length, are obtained. Alternate ribs are sectioned to prevent the collapse of any appreciable volume of lung. These segments of rib are then cut transversely into three pieces and these in turn are split longitudinally into splinters which measure roughly four centimeters in length and two or three millimeters in diameter. These splinters are placed in warm physiological saline solution to which are added two or three bloody sponges. Into the same container are placed the irregular fragments of the spinous processes which are obtained by the other operating team. (See Figure 1.)

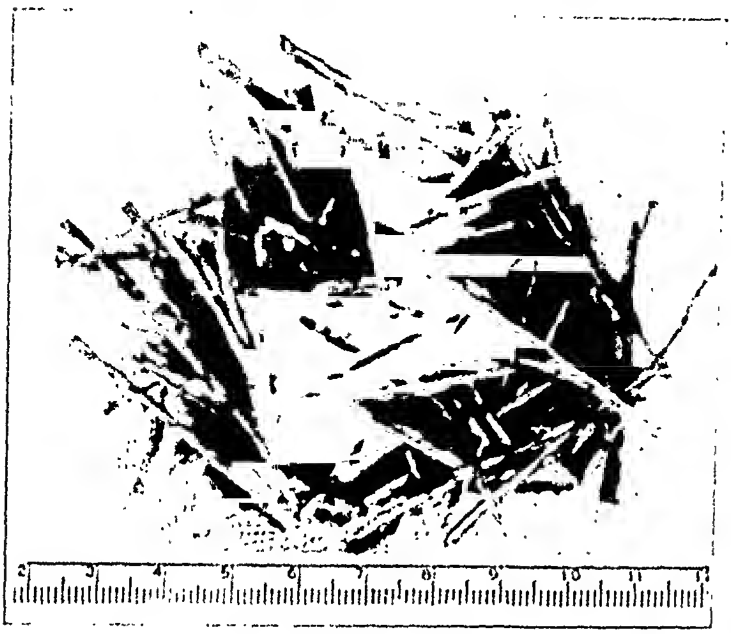

FIG. 1

Preparation of Graft Bed: An incision is made in the midline, from the tip of the third spinous process above to a similar distance below the involved (diseased) vertebrae. The dorsal fascia overlying the tips of the spinous processes and the interspinous ligaments, together with the periosteum over the process tips, are incised. Then, by careful dissection, this periosteum and part of the interspinous ligaments can be separated with the attached muscle bundles and retracted laterally. This procedure is carried on until the spinous processes and the laminae are denuded and the articulations are exposed. Sections of bone from the base of the spinous process and the laminae of each vertebra are then raised up with a small gouge or chisel and the spinous processes are sectioned at their bases. Destruction of the intervertebral joints is brought about by removing some of the cartilage and joint edges with a small chisel. (See Figure 2.)

To control bleeding, hot wet sponges are packed into one side of the wound while the other side is being worked on. When the bed has been thus prepared, the bone splinters obtained by the other team are packed into the wound. Each splinter is in intimate contact with the laminae and with each other, and they are roughly all in line.

Release of traction now allows the muscle bundles (erector spinae) to approach one another. A row of chromic gut sutures, deep in the muscle,

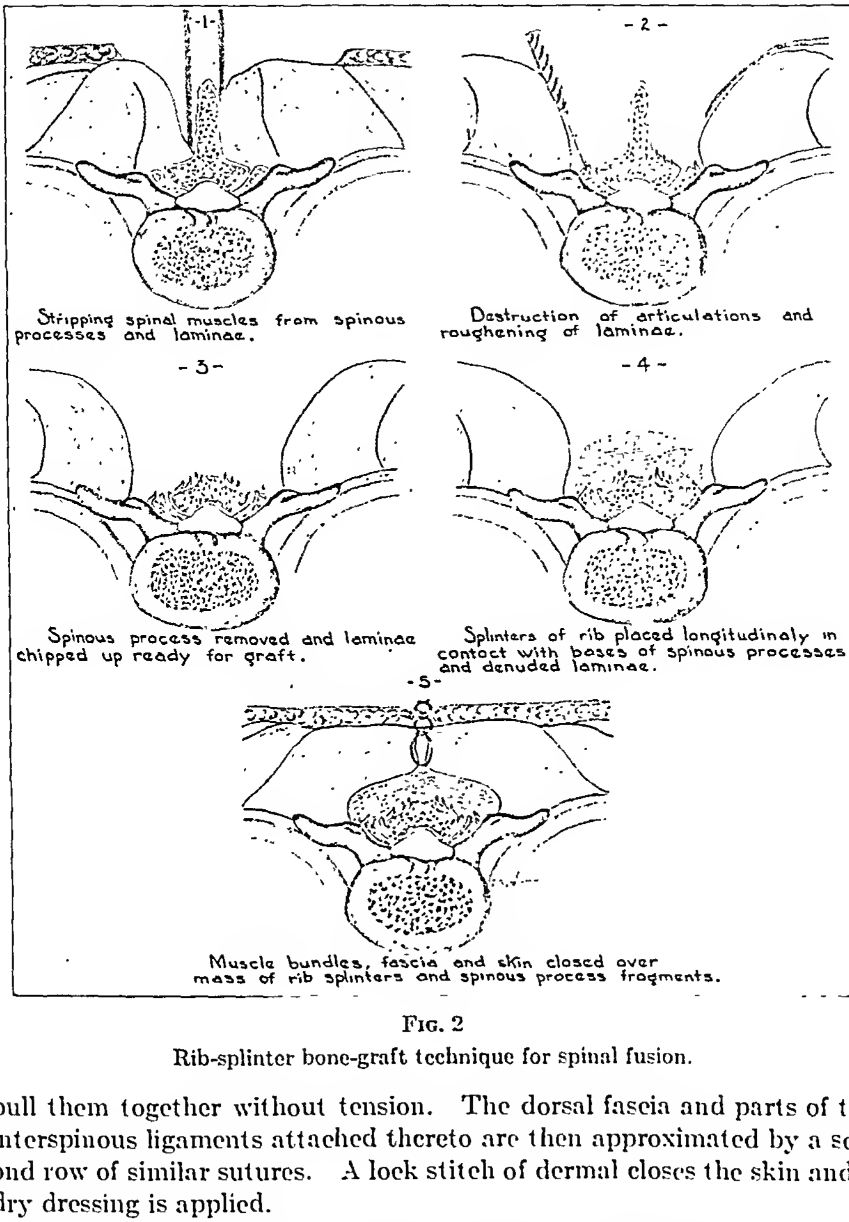

FIG. 2

Rib-splinter bone-graft technique for spinal fusion.

pull them together without tension. The dorsal fascia and parts of the interspinous ligaments attached thereto are then approximated by a second row of similar sutures. A lock stitch of dermal closes the skin and a dry dressing is applied.

For the first week to ten days, the patient is allowed to assume any horizontal position in which he is comfortable. The stitches are then removed and the patient is provided with a posterior plaster shell or instructed to lie continuously on a firm mattress. This choice of postoperative care depends upon whether or not the patient can be trained to remain on his back and to roll like a log when turning over. If he cannot, a plaster shell is provided.

Ninety days after operation, if the roentgenographic appearance of the diseased area permits, an Osgood brace is provided and the patient is

gradually allowed to get up. Postoperative observations on the three patients so far treated by this procedure show that at thirty-day intervals new bone formation in the graft is steadily on the increase. Compared with observations in representative cases in which cortical grafts are used, we find a much more rapid proliferation of bone where the rib splinters are used.

Since most patients with vertebral tuberculosis must be treated by prolonged recumbency, because of the complicating visceral lesions, immediate strength of graft is not of importance. Therefore, solid rib or tibial grafts, anchored to the laminae and the spinous processes, are not, in the author's opinion, of as much value as a graft which in itself will resist little if any strain early, but which later develops into a thick plate of solid bone, extending well out on the laminae laterally and from the spinous process of the second or third healthy vertebra above and below the diseased area. Solid cortical grafts, then, present immediate strength, but a low-grade proliferative power, while rib splinters, composed of fine periosteal shreds, cortex, and endosteum, possess a high degree of osteogenetic ability, although they have little to offer early as a support.

SUMMARY

In the method of spinal fusion described, in which splintered rib is used for the graft, the articular facets are destroyed, because it has been felt, as Haas shows experimentally, that this procedure produces firmer fixation.

This method presents the following distinct advantages over other types of fusion operations:

1. The operative trauma is slight.
2. An accessible graft source, which supplies cortex, medulla, and endosteum for osteogenesis, is used.
3. Osteogenesis is very rapid.
4. The resulting graft is broad and thick and is attached to the whole surface of the laminae.

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THE BÖHLER CLAVICULAR SPLINT IN THE TREATMENT OF CLAVICULAR INJURIES

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The use of the Böhler clavicular splint in the treatment of separation of the acromioclavicular joint has already been demonstrated[3, 5]. Since the publication of these cases the splint has been modified by Dr. J. E. Milgram to make it lighter and less cumbersome, and it has been used in the treatment of a variety of fractures of the clavicle with excellent results. The author believes that the apparatus is a worthy addition to the appliances used in the treatment of fractures of the clavicle. It provides for an important principle that is lacking in all of the methods used today.

The most common site of fracture is at the junction of the middle and outer thirds of the bone. The inner fragment is drawn upward by the pull of the sternocleidomastoid muscle, while the outer fragment tends to be drawn downward, forward, and toward the sternum by the pull of the pectoralis major and deltoid muscles. Most of the methods employed attempt to elevate and to retract the shoulder and with it the outer fragment, in the hope that it will bring the latter into alignment with the inner fragment, but no serious attempt is made to depress the inner fragment and to overcome the upward pull of the sternocleidomastoid muscle. The end result in most of these cases is overriding of the fragments and deformity at the fracture site.

An error commonly made is the application of some form of the numerous bandages or splints, with the expectation that the bandage or splint will effect reduction. The Sayre and Velpeau dressings do not reduce a fracture; they merely immobilize the shoulder and have the disadvantage of excoriating the skin. The T splint is advocated by the Fracture Committee of the American College of Surgeons[1], but Speed[2] comments on the fact that it does not elevate the shoulder and its usual result is some overriding of the fragments. The deformity that results from this method is due to the failure to provide downward traction on the inner fragment.

In order to effect reduction, it is necessary to raise the outer fragment, to correct the shortening by applying traction away from the chest, and, most important, to depress the inner fragment. The surgeon can best accomplish this by standing behind the patient, by placing the clenched fist in the axilla, by raising the shoulder, and (with the other hand against the patient's elbow) by pressing the elbow toward the patient's body. By this means, the overriding can be corrected. The inner fragment is then pressed down, and, in many cases of complete transverse fracture, the

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FIG. 1
Modified Böhler clavicular splint.

fragments can be hooked. To maintain this position and to prevent the inner fragment from slipping upward, the Böhler clavicular splint is used.

The author has described in detail the construction of the splint in previous communications. Briefy, the modified splint (Fig. 1) consists of a light board (*a*) of pine or balsa wood, five inches wide at the upper part, twelve inches long, and one inch thick. The board tapers down, the lower end being four inches wide. The upper part is rounded in concave fashion and is covered with thick felt to fit the axillary curve. Two malleable iron ribbons (*b* and *c*), twenty-six by one and one-half by one-eighth inches (the inner surface covered with felt, the outer with webbing), are attached to the main part of the board and are used to fasten the splint to the trunk. A third webbing (*d*) is fastened to the normal shoulder and is used to raise the splint and with it the in-

FIG. 2
The splint properly padded and applied.

FIG. 3
Case 1. Typical fracture of the clavicle at the junction of the middle and outer thirds, with upward displacement and overriding of the inner fragment.

Fig. 4
Case 1. Fracture reduced and maintained by clavicular splint.

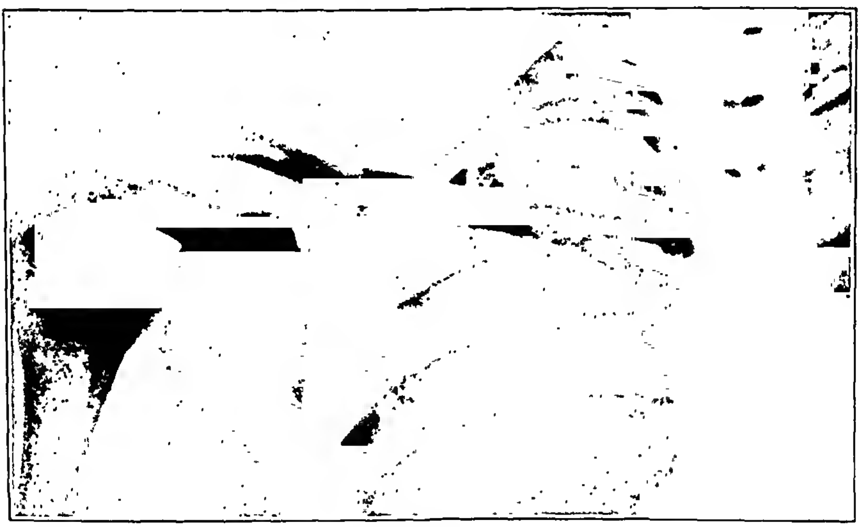

Fig. 5
Case 1. Four weeks after reduction. The splint has been removed and there is good alignment of the fragments.

jured shoulder. A fourth belt (*c*), with a buckle, is introduced under the lower iron ribbon and is used to press down the inner portion of the clavicle. (It is this belt that is the most important feature of the apparatus. Downward traction with adhesive strips is sometimes attempted, but retraction of the skin nullifies its effect, if any.) All parts are well padded and a small piece of felt is placed over the portion of the clavicle that is to be depressed. For children, a proportionately smaller size is used.

FIG. 6

Case 2. Oblique fracture of the clavicle in a female, aged sixty, with a loose fragment of bone at the site of fracture.

FIG. 7

Case 2. Six weeks after reduction. The splint has been removed and there is good alignment of the fragments.

The apparatus can be worn without discomfort (Fig. 2). Once fastened it needs little adjustment. The only care required is to tighten the buckle of the belt going over the injured shoulder in order to increase the pressure when needed. The extremity is free at all times; one need not fear stiffness of the shoulder or elbow, or subsequent atrophy of the muscles which often results when the extremity is completely immobilized against the chest wall. Once reduced, the fragments remain reduced, and, because of the fixed pressure of the webbing over the inner fragment, displacement cannot occur. The patient is ambulatory and does not require hospitalization.

This apparatus has been used successfully in the treatment of a number of different types of clavicular injuries. The following case reports will demonstrate the effectiveness of the splint.

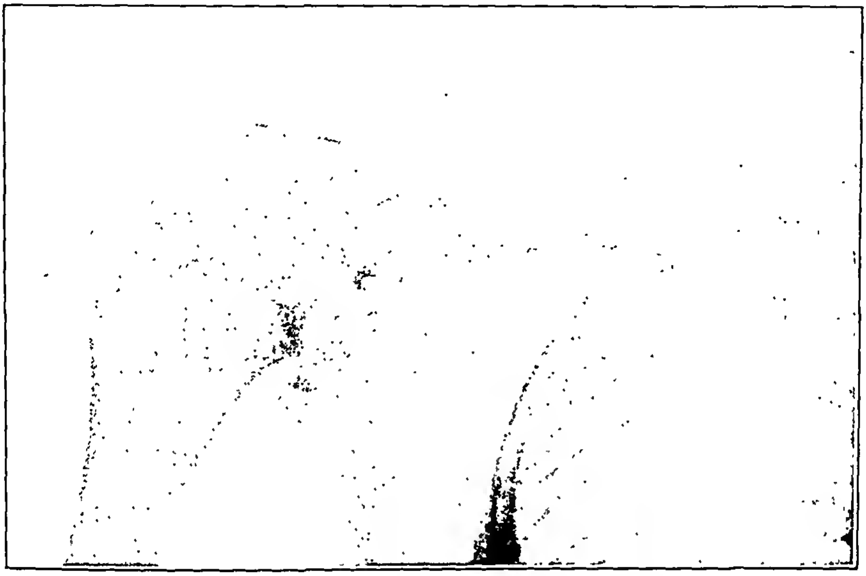

FIG. 8

Case 3. Fracture of the outer end of the clavicle, with tearing of the coraco-clavicular ligaments.

FIG. 9

Case 3. Six weeks after reduction, following removal of the splint.

FIG. 10

Case 4. Fracture of the inferior surface of the outer third of the clavicle and an oblique fracture through the acromial end.

FIG. 11

Case 4. Alignment obtained after six weeks' treatment with the clavicular splint.

CASE REPORTS

CASE 1. A girl, aged ten, sustained a fracture of the right clavicle. A roentgenogram (Fig. 3) showed a complete transverse fracture at about the junction of the middle and outer thirds of the bone with upward displacement and overriding of the inner fragment. This is the typical form of fracture that is generally treated with a Sayre or Velpeau bandage or with a T splint, resulting in a deformity of the bone with a visible lump which is a very distressing feature.

Under local anaesthesia (five cubic centimeters of 2-per-cent. novocain), the fracture was reduced by the method described and the fragments were hooked (Fig. 4). The

splint was then applied and maintained for three weeks. The patient was observed every other day for the first week and the belt holding down the inner fragment was adjusted and tightened. A roentgenogram (Fig. 5), taken after removal of the splint, showed the alignment had been maintained, and that callus was present. In a few days, without after-treatment, the patient had a complete range of motion in the shoulder.

Case 2. A female, aged sixty, was seen with a fracture of the outer portion of the middle third of the clavicle (Fig. 6); a loose fragment of bone was present at the site of fracture. In this type of fracture the fragments could not be hooked, but excellent alignment was obtained by depressing the inner fragment and by maintaining the position until callus had formed. Figure 7 shows the result six weeks after reduction.

Case 3. A girl, aged sixteen, sustained a fracture of the outer end of the clavicle (Fig. 8). In this form of injury there must be some tearing of the coracoclavicular ligaments. Open operation was advised by several as being the only means of approximating the fragments. However, by maintaining constant downward pressure on the shaft of the bone with the Böhler clavicular splint, the fragments were held in apposition until united by firm callus. The apparatus was maintained for six weeks. Not only was union obtained at the area of fracture (Fig. 9), but the torn coracoclavicular ligaments were healed as in cases of acromioclavicular separation where healing was obtained in the torn acromioclavicular ligaments. This case was reported in detail in a previous communication[4].

Case 4. A laborer, aged thirty-two, was struck by a truck, and sustained an injury to the right shoulder. There was considerable disability of the shoulder joint with swelling and deformity at the outer end of the clavicle. A roentgenogram (Fig. 10) showed a fracture of the inferior surface of the outer third of the clavicle, with separation of the bone from the shaft; and an oblique fracture through the acromial end of the clavicle, with angulation at the fracture site. There was also an incomplete dislocation of the acromioclavicular joint. This patient was seen one week after injury and had been treated with several forms of appliances and dressings without any improvement in the nature of the fracture. By means of the Böhler splint, pressure was exerted downward on the outer half of the bone and maintained for six weeks. A roentgenogram (Fig. 11), taken at the end of this period, showed excellent alignment and union. The patient returned to his work of delivering ice, several weeks later, without disability.

A word of caution against using this form of treatment in fractures of the inner half of the bone is necessary. In this type of fracture, especially in an individual with a short, thick neck, it is not possible to apply the pressure over the inner fragment. The webbing will slip over to the outer fragment and the pressure on that portion of the bone will cause a greater deformity.

SUMMARY

1. The methods commonly used in the treatment of fractures of the clavicle have received unfavorable comment by many authors.

2. The Böhler clavicular splint is advocated for use in the treatment of a variety of fractures of the outer third of the clavicle, where downward pressure on the inner fragment is required.

3. The patients are ambulatory and have complete use of the extremity at all times; thus stiffness of the shoulder and elbow joints and atrophy of the muscles are avoided.

FIG. 1

X-ray 16 days after fracture. Untreated.

FIG. 2

X-ray 16 days after fracture. Treated 4 days after fracture with amniotic fluid T-597.

An attempt will be made to show in the accompanying illustrations the difference in density and size of callus and speed of repair in the treated legs, also the earlier medullary recanalization and homogeneous blending of bone at the sites of repair in those legs treated with amniotic fluid and its fractions.

In this work, as in all animal experimental work, individual variability of the animals made control by animal against animal less accurate than leg against leg in the same animal.

ROENTGENOGRAPHIC FINDINGS

Figure 1 shows the fracture sites in an untreated control animal. Because the bones are superimposed in one view, an impression of solidity is inferred, which is not borne out by the other view. With suitable allowance for this discrepancy, both legs show the same degree of repair.

Figure 2 shows the legs of an animal in which a fraction of amniotic fluid T-597 was injected into the sites of fracture of the right leg four days after the bones had been broken. At the same time salt solution was injected into the left leg at the sites of fracture. Injections were given to this animal every four days until three injections had been given. On the sixteenth day the casts were removed and the legs were x-rayed.

Attention is called to the degree of repair in the right or treated leg

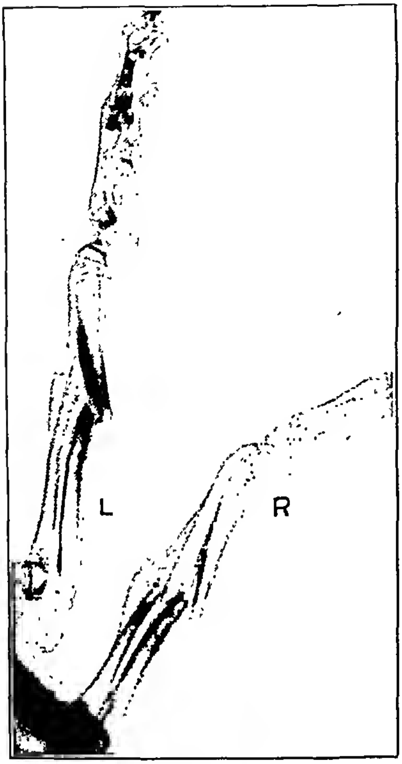

Fig. 3

X-ray 16 days after fracture. Treated with amniotic fluid T-890.

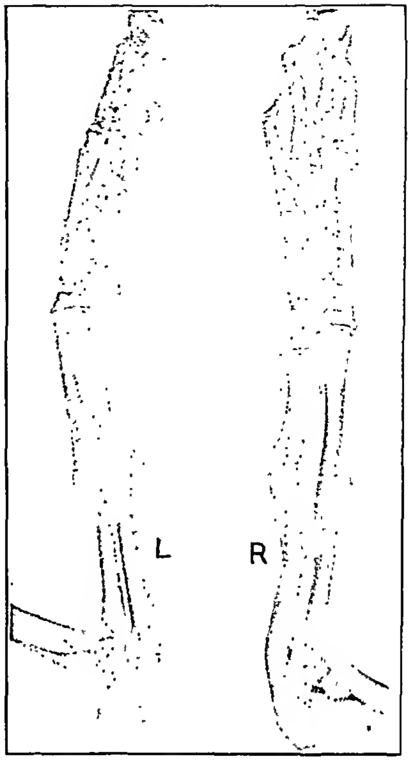

Fig. 4

X-ray 16 days after fracture. Treated with amniotic fluid T-890.

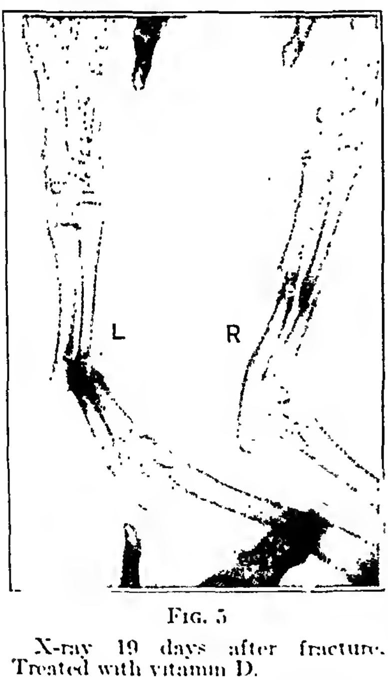

Fig. 5

X-ray 19 days after fracture. Treated with vitamin D.

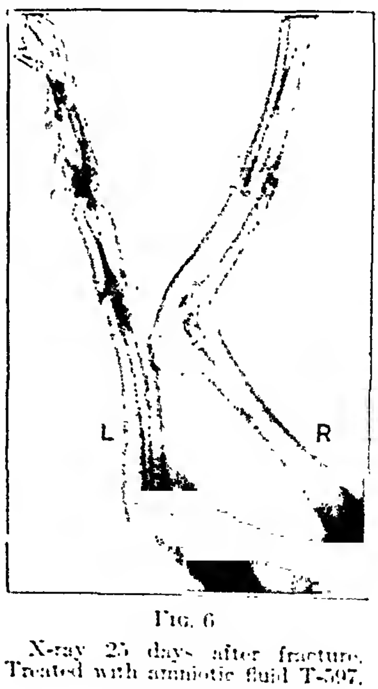

Fig. 6

X-ray 25 days after fracture. Treated with amniotic fluid T-597.

as compared to the control leg which was injected with salt solution. It may be noted that calcification of the callus in the treated leg has progressed to a more advanced stage of repair than in the control leg. This may be measured by the density of the callus and by the size of the

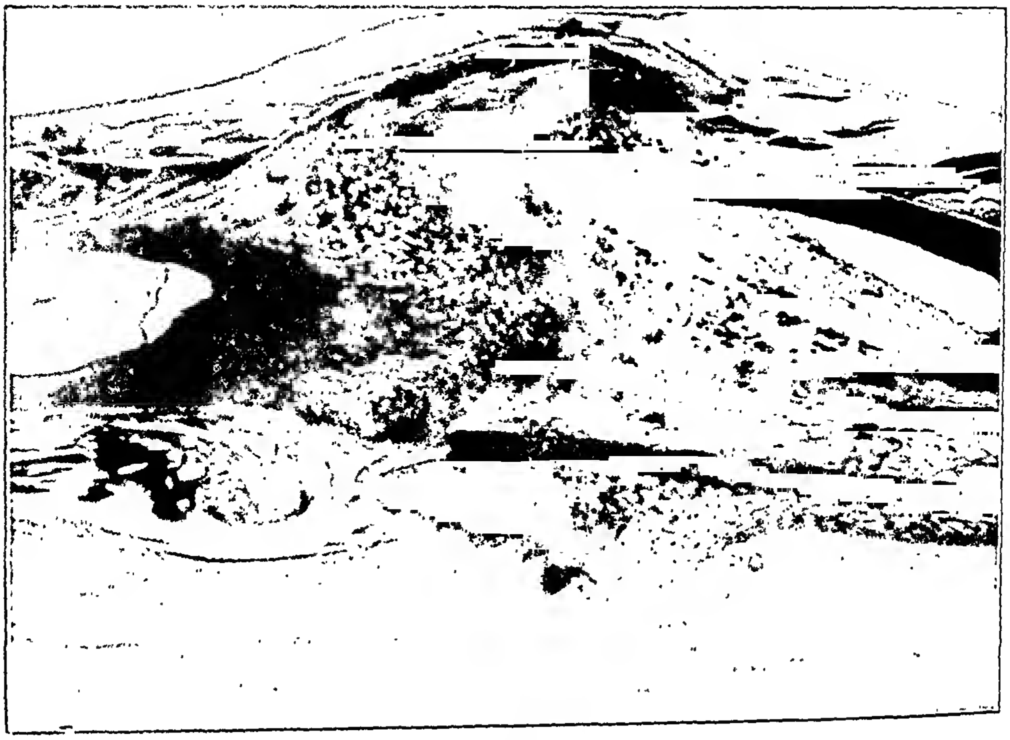

FIG. 7
Photomicrograph 25 days after injection of normal saline.

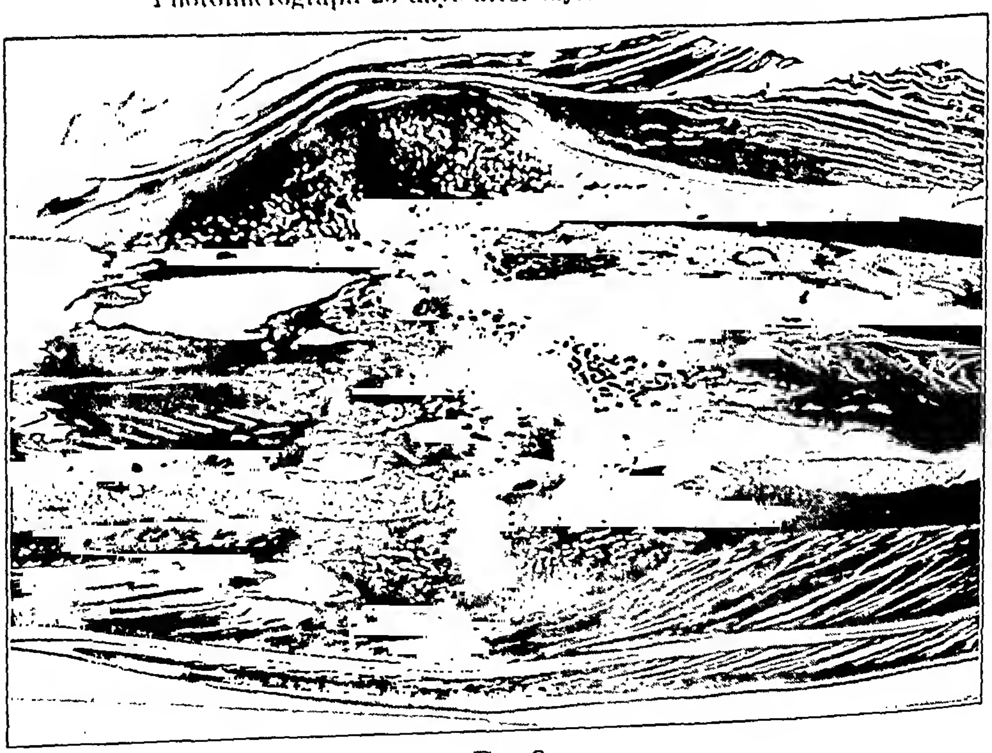

FIG. 8
Photomicrograph 25 days after injection with amniotic fluid T-597.

uncalcified gap in the control leg as against the almost complete obliteration of this gap in the treated leg.

Figure 3, the roentgenogram of an animal treated with a different preparation of amniotic fluid, T-890, shows about the same results as Figure 2. By comparison, a more advanced state of repair will be noted in the treated leg than in the leg injected with salt solution.

Figure 4, the roentgenogram of another animal treated with amniotic fluid T-890, offers further evidence of the value of this substance in promoting bone repair. There is completion of the callus outline with calcification in the right leg as compared with the incompletely calcified gap in the left leg. The callus in the right leg appears more dense than that in the left leg.

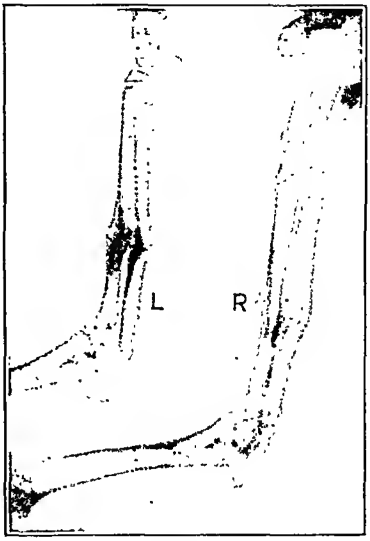

Fig. 9

X-ray 25 days after fracture. One injection of amniotic fluid T-597.

Figure 5 is the roentgenogram of an animal treated by concentrated vitamin-D injections and x-rayed on the nineteenth day. The bone repair is similar to that noted in untreated control animals.

Figure 6 shows the legs of a mature large rabbit, one year old, treated by a concentrated fraction of amniotic fluid T-597 and x-rayed on the twenty-fifth day. The degree of bone repair in treated and in control legs is quite similar to that noted in the young rabbit at sixteen days. This illustration is shown to demonstrate the relative speed of repair as compared to that in younger rabbits. The effect on this animal of stimulation by amniotic fluid is consistent, although repair was delayed. Because of the size of the uncalcified gap in the left leg, as shown roentgenographically, it was feared that some soft tissue might have been interposed between the fragments, thus delaying union. The animal was sacrificed and longitudinal sections from both fracture sites were made for histological study. Sections of this particular animal were rushed through to determine what type of tissue composed the rather large gap separating the bone ends. This region in the left or control leg (Fig. 7) is formed of cartilage, osteoid and osteoblastic tissue, and young callus. In the treated leg (Fig. 8) a narrow zone of cartilage and callus fills the gap.

Figure 9 is the roentgenogram of a young rabbit treated by one injection of amniotic fluid T-597 into the right leg at the time of fracture. Saline was injected into the left leg as a control. The injections were not repeated. The animal was x-rayed twenty-five days after fracture. The comparative results are striking.—in the right leg an advanced state of repair is apparent, including recanalization of the medullary cavity and complete bony union at the fracture sites.

In the untreated leg dense calcification may be seen at the sites of fracture, but the repair process obviously has not progressed to the degree noted in the treated leg.

SUMMARY AND CONCLUSIONS

Observations on a series of thirty-six animals are submitted to show the comparative stimulating effect of selected substances on the repair of fresh fractures when injected into the site of injury.

Leg-against-leg control in the same animal tends to eliminate discrepancies due to individual variability where animal is compared with animal.

Of the selected substances employed as stimulants to bone repair, amniotic-fluid concentrate gave the only definite results.

Injection may be done at the time of fracture or it may be delayed for from one to four days.

The results obtained in this experimental series suggest the clinical application of this treatment to fresh fractures in sites notorious for delayed union or non-union of bone.

SOME FACTORS WHICH INFLUENCE THE BALANCE OF THE FOOT IN WALKING

THE STANCE PHASE OF GAIT *

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This subject is old. The method of investigation is different, if not new. The beginning of modern medicine includes references to the treatment of deformities of the feet. One finds also that the history of orthopaedic surgery requires generous space for a record of the multiplicity of efforts made to relieve discomfort in feet which were free from gross abnormal contours. Many text-books have described methods of treatment to relieve the symptoms. The young surgeon, with initial confidence, accepts them as informative. Time and experience with patients foster reservations regarding these text-book methods as each orthopaedic surgeon develops his personal method of treating painful feet.

Common physical and physiological factors are present in feet which are painful. The variable with relation to methods of treatment is expressed by those who prescribe for such patients. Each one of us may in personal confidence be satisfied with our individual solutions for the prevailing problems. However, such professional equilibrium finds continuity with empiricism, impressions resulting from trial and error. It becomes disturbed when all the various and bizarre methods of treatment are subjected to a basic premise resulting from recorded analyses of gait

An interest in the phenomena of human locomotion has been sustained by one of us (R. P. S.) since 1919. Since September 1926, research on this subject has been in progress. Through this effort, instruments of precision essential to the analysis of gait have been developed. From the resulting records of "normal", lame, deformed, and hysterical subjects, certain concepts regarding the way we walk can be based upon reaction of the individual to prevailing methods of investigation. Thus removed from the conjectures and errors of visual analysis, the accumulation of 2,500 electrobasographic records reveals the indication for the presentation of facts relevant to a particular phase of the whole problem of human locomotion. In reality, the present discussion is limited to the stance phase of "normal" gait. This phase of gait is defined as the time interval between the placing of the heel and the lifting of the great toe from the floor. It is illustrated in Figure 1.

* Read at the Annual Meeting of the American Orthopaedic Association, Milwaukee, Wisconsin, May 20, 1936.

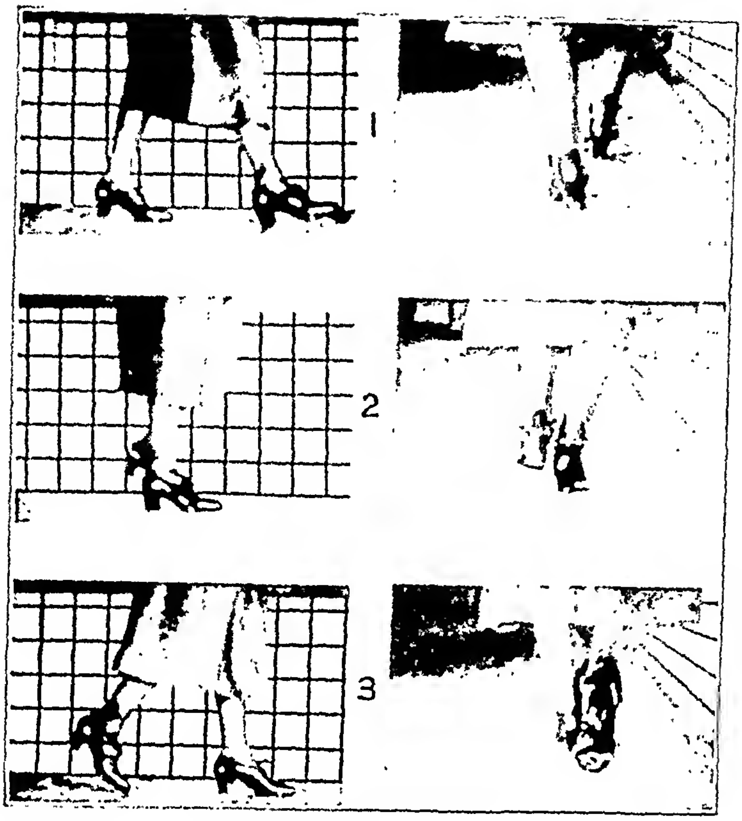


FIG. 1

Stance phase of right foot: 1=heel contact; 2=full weight-bearing; 3=elevation of forefoot from the floor.

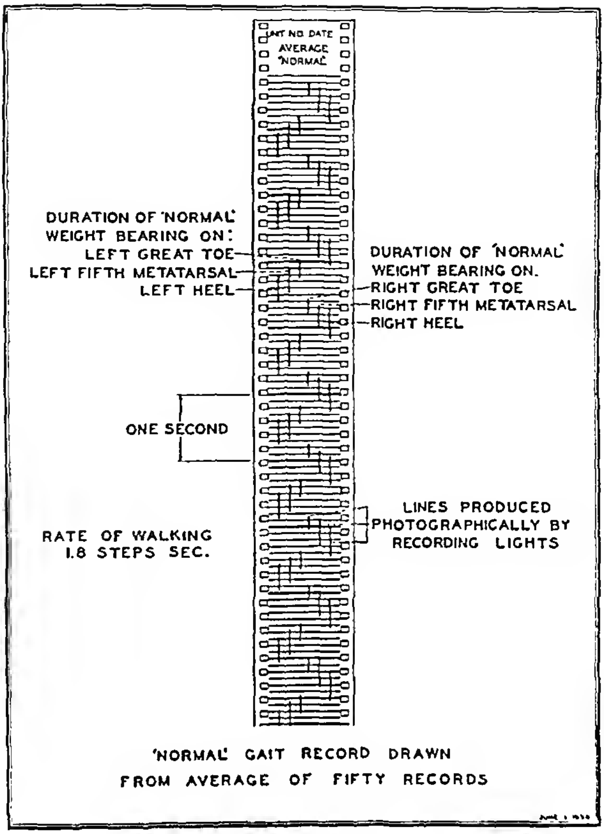
It is agreed that pronation, variable in degree, may exist in such a weight-bearing foot. Moreover, it is common to observe local and referred symptoms in association with such pronation. The converse is also true,—*i.e.*, these characteristic symptoms almost never prevail in the absence of pronation. It must be stated with emphasis, however, that some pronated feet are not painful. All such feet, with or without symptoms, function in a position which produces strain on all structures that are in abnormal relationships. They are, therefore, not in balance required for normal function, free from strain and from potential or prevailing symptoms associated therewith. When free from all other abnormalities, a foot can be in balance only when it functions without prevailing pronation.

For the purpose of mutual understanding, the feet may be regarded as semimobile structures on and by which the superimposed weight of the body is propelled. The optimum relationship of osteo-articular structures in and related to the feet is maintained by the preservation of normal muscle function in walking.

In the order of normal weight-bearing, the foot has two divisions,—the heel and the midfoot. The forefoot is a mechanism essential to propulsion of the body; its weight-bearing function is secondary. These are simple facts which would not seem to require proof for acceptance. In the presence of doubt, there is an abundance of evidence to support each specific statement.

Moreover, it is obvious that such evidence must come from one or more methods devised to study the function of the foot in motion. Much may be learned by simple observation of successive individuals in groups representing known conditions. This was proved by Cross, Thomas, Golding-Bird, Walsham and Hughes, and others in the past century. The disadvantages of this method are revealed by limitations in the

powers of visualization, when applied to the analysis of function of the foot while the subject walks. These limitations result from the complexity of the act of walking, and are expressed both by errors of omission and of commission. In this respect, the study of gait as applied to the foot required the application of physical laws for more accurate knowledge, as was true with respect to cardiac function, to the function of the gastro-intestinal tract, etc.



'NORMAL' GAIT RECORD DRAWN FROM AVERAGE OF FIFTY RECORDS

Fig. 2

The principle of the electrobasograph has been previously described. The "electrical footprints" recorded by this instrument bear a close relationship to information essential for a better understanding of human locomotion.

The average record of normal gait is presented in Figure 2. It defines foot function in relation to three important time intervals: (1) the duration of time spent on the heel, the midfoot, and the forefoot; (2) the time sequence in which weight is received on the midfoot and on the forefoot; and (3) the time sequence in which weight is delivered from the heel to the midfoot, and from the midfoot to the forefoot. It must be evident that such recording of foot function to the thousandth of a second would also include the total duration of time for the stance phase, the period of double weight-bearing, the swing phase, and the period of overlap in weight-bearing on heel and forefoot in each step, as related to the respective feet. These measurements are essential to the academic understanding of human gait. It is true, moreover, that they become of equal importance to the solution of the common every-day problem of pronation.

To clarify these assertions, let us recall the prevailing structural relationships between the foot and the leg. The bones of the foot form a semimobile unit. Mortised between the malleoli, the astragalus articulates it with the tibia and the fibula. (Full consideration cannot now be

given to this complicated articulation of the ankle which is made to appear simple by its most obvious range of motion.) The posterior view of the skeleton reveals a disparity of alignment between the foot and the leg (Fig. 3).

The axis of weight-bearing of the tibia passes through the middle of the astragalus. The axis of weight-bearing of the os calcis is displaced laterally from one to one and five-tenths centimeters. Such malalignment between the tibia and the os calcis is normal. This, together with other commonly prevailing characteristics of the os calcis, provokes influences which further the instability between these strong and rigid bones.

At this point, it is desirable to omit the enumeration of each of the normally related influences which combine to make the foot an unstable osseous weight-bearing structure in relation to the tibia and the fibula. A more simple consideration may provide a better understanding of our subject. Let us visualize the bones of the foot and the leg which are united by the normal ligamentous capsules of the articulations. Under the influence of superincumbent weight, there is great distortion of contours from the normal definitions. These deviations from normal express a constant in one direction. The greatest evidence of change is naturally present where the foot is most mobile. This medioplantar deviation is most obviously related to the medial border of the foot at the level of the astragaloscaphoid joint. The end stage of deformity in this direction is illustrated in Figure 4.

Such evidence requires the presentation of facts which are of major importance. It has been conclusively demonstrated that normal foot contours are not retained by virtue of the shape of the bones and of the strength of the connecting ligamentous capsules. These demonstrations prove most conclu-

FIG. 3

The malalignment of the weight-bearing axis of the tibia with that of the *os calcis* favors instability of the foot on the medial side. There is a difference here of 1.2 centimeters. (*Courtesy of The Physiotherapy Review.*)

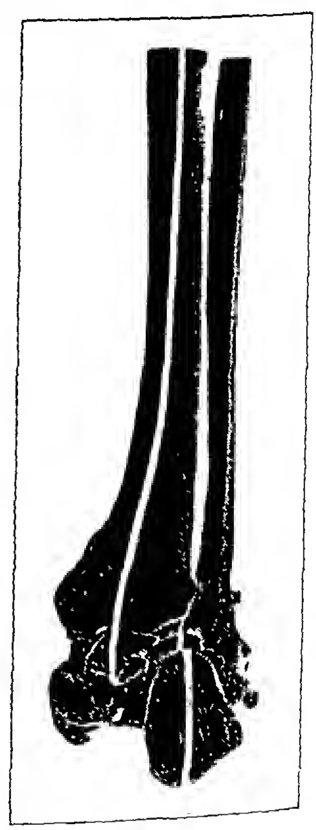


FIG. 4

Maximum deformity, structural flat-foot. There is a difference of 2 centimeters between the weight-bearing axis of the tibia and of the os calcis.

sively that the opposite statement is true. When the bones of the foot and the leg are joined only by their ligamentous capsules, their relationship is distorted in the weaker position of pronation when downward pressure is applied to the tibia.

In this respect, the bones of the foot structurally present a relationship to each other which favors instability in the direction of pronation. We cannot ignore indisputable evidence which claims the need for supporting structures essential for maintaining foot contours which are commonly regarded as normal.

Muscle and related tendinous structures, which function normally under voluntary control, prevent foot deformities which would otherwise be inevitable. We readily appreciate that muscle strength alone is less important than the question of balance in functional strength and mechanical advantage in groups of opposing muscles under voluntary function,—a fact of great importance.

Both intrinsic and extrinsic muscles with their respective tendons are the essential structures upon which the foot is completely dependent for balance in walking. Of these two, the extrinsic group has the predominant influence.

We are all familiar with the muscles forming this group. We can visualize their proportionate size and course in their respective positions on the posterior, lateral, anterior, and medial aspects of the leg.

The posterior group—the peronei and the tibialis posterior, which initiate plantar flexion, and the gastrocnemius and soleus, which lift the body weight—does the most work in normal walking. The antagonistic anterior group of muscles is much weaker. The gastrocnemius, in relation to its origin and insertion, frequently precludes the possibility of avoiding pronation when the subject walks without elevation of the heels. Moreover, the relationship of the tendo achillis to pronation becomes of particular importance because of the disparity in alignment between the os calcis and the tibia. The prevailing limitation in dorsiflexion, without pronation, while the knee is fully extended, is frequently associated with "contracture" of these posterior structures as a dominating cause. In such instances, treatment directed only at the medial aspect of the foot cannot by and in itself be effective. The muscles which control the medial and lateral aspects of the foot can never prevent pronation in the presence of these two causes,—malalignment of the weight-bearing axis of the os calcis, and "contracture" of the tendo achillis.

These extrinsic muscles of the leg send to the foot their strong tendons. Structurally, they are arranged to form a tendinous sling in which the bones of the foot are suspended. In fact, this is the only mechanism upon which the foot can depend for protection against the development of abnormal contours. The prevailing balance in the efficiency of normal muscle function determines the presence or absence of balance in the foot as related to pronation and associated functional strain. Moreover, this balance in muscle function must work against the inherent instability

FIG. 5

Medioplantar view of the tendinous sling. Tibialis anterior, tibialis posterior, flexor digitorum longus, flexor hallucis longus, and peroneus longus, from above down.

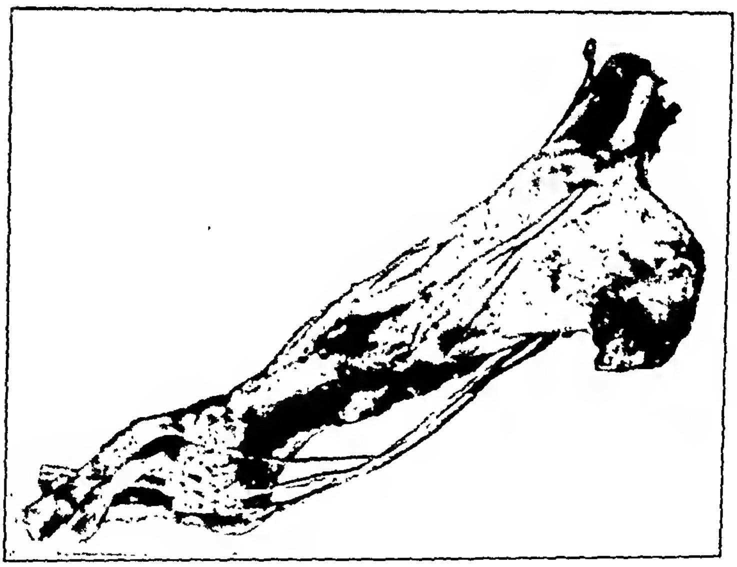


FIG. 6

Lateral view. Peroneus longus paralleled by the peroneus brevis which inserts on the cuboid.

resulting from the malalignment of the tibia and the os calcis, and the associated relationship of the gastrocnemius and the soleus, to which reference has already been made.

Dissections of the foot, revealing the course and insertions of these extrinsic muscles, present most clearly the tendinous sling that they provide for support to the bones and the articulations which they surround. The medioplantar view reveals, from above down, the tibialis anterior and the tibialis posterior which control the varus position of the forefoot and the midfoot respectively (Fig. 5). The flexor digitorum longus and flexor hallucis longus gain an effective leverage in passing from the posterior border of the internal malleolus to their respective insertions. The peroneus longus can be seen as it passes over the inferior surface of the cuboid anteriorly and medially to insert on the plantar surface of the base of the first metatarsal. The course and level of the insertion of the tibialis anterior and the peroneus longus make them true antagonists. The flexor digitorum longus and flexor hallucis longus are joined at the point of crossing. This union is of a particular character with relation to function. Contracture of the flexor hallucis longus is accompanied by flexion of the four lateral toes, due to this area of tendinous attachment. The converse is less true. Moving-picture records reveal that the great toe flexes only a little when flexion

of the four lateral toes results from a pull on the flexor digitorum longus.

The course of the peroneus longus from the posterior border of the external malleolus is paralleled by that of the peroneus brevis to the level of the cuboid where the latter is inserted, as revealed in the lateral view (Fig. 6).

Observation of this same dissection from the posteroplantar aspect combines these two views of the tendons which suspend the bones of the foot (Fig. 7). This additional evidence of their intimate relationship to the bones of the leg and the foot is most positive. *At present, however, the correlation of extrinsic tendons to bones of the leg and the foot is significant only in the relationship which it bears to function of the foot in balance.*

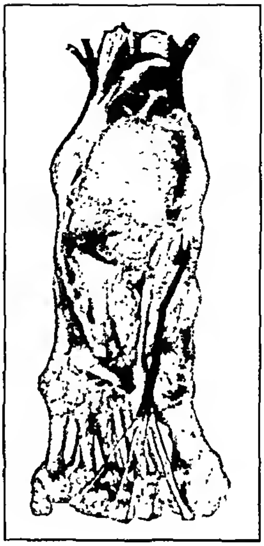


Fig. 7

Posteroplantar view combining that which is shown in Figs. 5 and 6 to reveal the tendinous sling provided by the strong intrinsic muscles to maintain normal foot contours.

At this point, it is essential to review the causes of abnormal balance which have been presented with evidence. The disparity in alignment between the weight-bearing axis of the tibia and the os calcis is a primary cause of pronation. The ligamentous capsules of the joints, particularly of the calcaneoscaphoid joint, cannot prevent the development of this or of any other abnormal relationship between the bones. The extrinsic muscles of the foot, through their tendons which suspend the bones of the foot, can prevent pronation only when their functional balance is efficient in counteracting the malrelationship normally existing between the tibia and the os calcis, and the other factors which favor instability.

The consideration of the treatment of pronation, therefore, must include consideration of all of these major factors. Acceptance of the premise, based upon the facts enumerated, and of the resulting conclusions directs attention to the foot and the leg as a unit. No reason need be given to justify the removal of the cause of any prevailing symptoms. In this instance, our premise indicates that both intrinsic osteo-articular and extrinsic musculotendinous influences combine to throw an apparently normal foot out of balance in walking. Treatment must, therefore, be directed toward these two causes.

These intrinsic osteo-articular and extrinsic musculotendinous structures may be defined and appreciation of their relationships may be acquired by the study of dissections, but there is still another requirement to be met. They must be visualized in motion while the foot and the leg are considered as a unit during the reflex act of walking. The electrobasographic records reduce the intricate and complex functional interrelationships to a common denominator, previously defined in terms of time intervals. These apply to each foot and are obtained while the subject walks at a natural, uninstructed rate.

TABLE I

HEEL-FOREFOOT OVERLAP

Foot	Street Shoes Seconds	Duty Shoes Seconds	Difference Seconds
Right	0.220	0.063	0.157
Left	0.189	0.048	0.141

TABLE II

PERCENTAGE OF TOTAL WEIGHT-BEARING TIME SPENT IN HEEL-FOREFOOT OVERLAP

Foot	Street Shoes Per Cent.	Duty Shoes Per Cent.	Difference Per Cent.
Right	34.3	9.8	24.5
Left	29.6	7.5	22.1

Through and in relation to all of this detail, we are still mindful of our objective. The more accurate definition of cause is essential to the most rational direction of treatment for any prevailing abnormality.

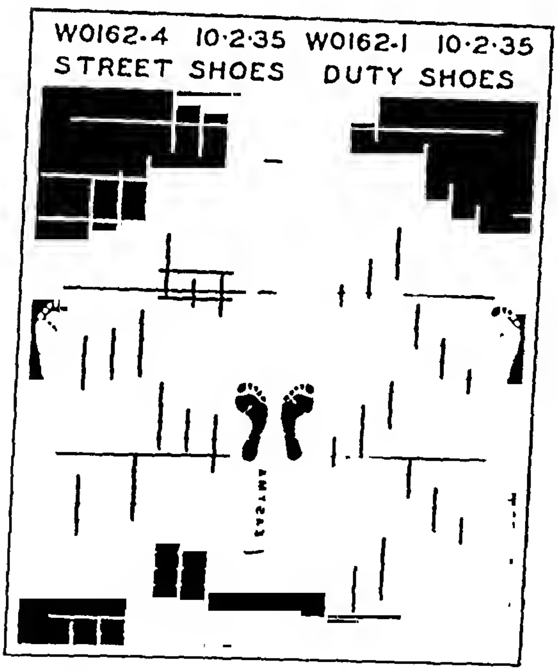


FIG. 8

In record W0162-4, the period of overlap in weight-bearing on heel and forefoot is indicated by the time interval between respective horizontal lines. Pronation was present. In record W0162-1, there was no overlap in relation to weight-bearing on heel and forefoot with duty shoes. *Pronation was absent.* (*Courtesy of The Physiotherapy Review.*)

Such accumulated records have brought much evidence to bear on the whole problem of human locomotion. Early in our work, it became apparent that balance of the foot was greatly influenced by the character of the shoes worn by the subject. Certain phases of these observations were later reported.

Further investigation warrants the belief that the extrinsic neuromuscular and tendinous structures, in association with all of the other structures which reflexively activate human locomotion, constitute an extremely delicate and sensitive mechanism.

This sensitivity is revealed in the presence of influences adverse to the foot's most efficient function. One common example of

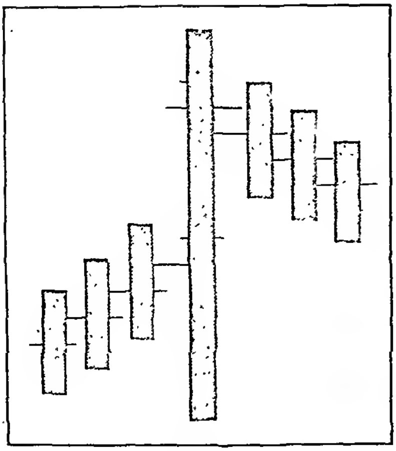


FIG. 9-A

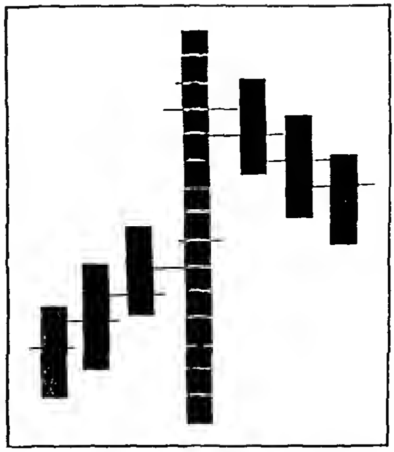


FIG. 9-B

Graphic presentation of averages for the gait records of twenty-four nurses. The middle bar represents 1.5 seconds. The heel, midfoot, and forefoot are represented on the respective sides (see normal record). Fig. 9-B (duty shoes) is superimposed on Fig. 9-A (street shoes) in Fig. 9-C. Note the heel-forefoot overlap in Fig. 9-A and the difference in distribution of weight-bearing in Fig. 9-B.

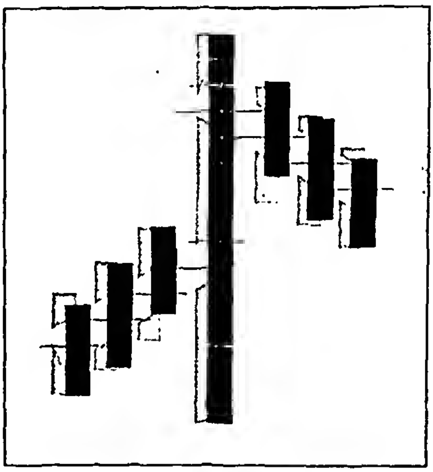


FIG. 9-C

such influences is predominantly expressed in the relationship of shoes to feet. In many instances, shoes, made without regard for the natural and essential balance of the "normal" foot in walking, produce adverse influences beyond the natural power of compensation for their presence.

This important cause of imbalance was strikingly revealed in the records of twenty-four nurses. These were normal girls entering the training school at the average age of nineteen years. It seems reasonable to believe that they should have possessed the average ability to compensate for influences detrimental to normal balance of the foot while walking. Electrobasographic records were made while the subjects were wearing their own street shoes which they had brought from different cities. These shoes gave a fair average of conventional shoe design.

Immediately after the girls had removed their street shoes and had put on duty shoes, similar gait records were made. These duty shoes had been made in accordance with our analysis of the requirements for balance of the normal foot while walking.

Measurements taken from all of these records have given expression to averages. Enumeration of all of the various averages might be con-

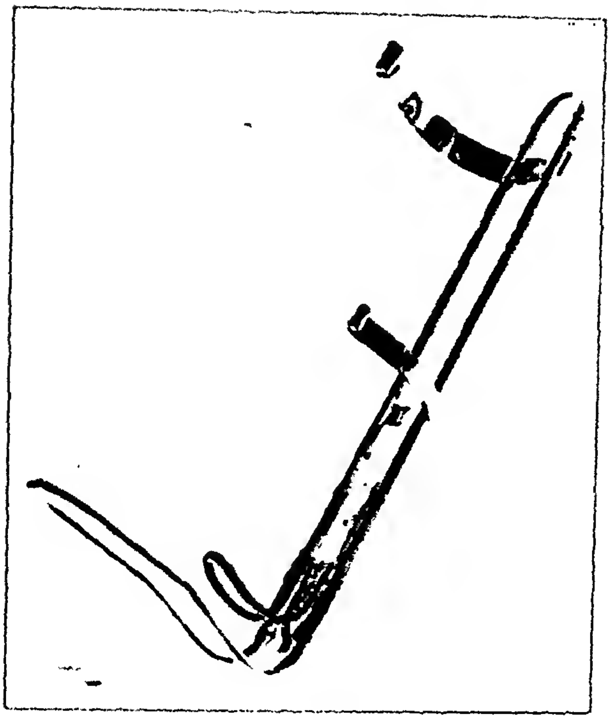


FIG. 10

Heel meter for determining the correct heel-height of shoe for each individual.

fusing, and, if not, they would only confirm the results as expressed by the period of overlap in weight-bearing on the heel and the forefoot of the respective feet. Previous reference has been made to this period of the stance phase of normal human locomotion. It may be defined as the interval of time during which the heel and the forefoot are simultaneously in contact with the floor at any rate of walking.

As illustrated in Figure 8, Record W0162-4 represents the gait of one of the nurses while she was walking in her street shoes. The horizontal lines drawn across the respective steps reveal this period of overlap in weight-bearing on the heel and the forefoot. Under the influence of maximum pronation, there is no weight-bearing on the lateral border of the foot. A partial expression of this fact is revealed in this record. It is indicated by the short duration of weight-bearing time on the midfoot in certain steps. These street shoes had been made with reference only to the foot at rest, having no regard for the balance of the foot in motion. Like a weight which throws a revolving wheel out of balance, these conventional shoes hung on the feet of these nurses. They were a malinfluence, against which the normal reflex mechanism could not compensate for the expression of normal balance of the foot in the stance phase of gait.

Record W0162-1 in Figure 8 represents the gait of the same girl while walking in duty shoes which were constructed in Rochester. They were made to express principles essential to balance of the foot, as has been defined in relation to the stance phase of gait. Gadgets were not used in this work. The illustration is typical of the evidence which defines a difference in function when the foot is relieved from the malinfluence of conventional shoes. While the subject was walking in the duty shoes, there was little or no overlap in weight-bearing time on the heel and the forefoot. This one measurement proves that the prevailing degree of pronation present in the street shoes was absent in the duty shoes. The latter shoes did not inhibit the normal sequence of weight-bearing on the three areas of each foot. The stable lateral border of the foot received the body weight from the heel, leaving the forefoot free for the essential function of propulsion (Figs. 9-A, 9-B, and 9-C).

The total overlap in the duration of weight-bearing on heel and forefoot was averaged from the records made with these shoes. This time interval for the "normal" gait record (Fig. 2) was 13.8 per cent. (right) and 11.0 per cent. (left) of the total time for the stance phase of the respective steps. As these figures increase, we know that the foot is more pronated; therefore, more out of balance. The street shoes gave an average of 34.3 per cent. for the right heel-forefoot overlap and 29.6 per cent. for the left heel-forefoot overlap. The duty shoes gave an average of 9.8 per cent. for the right heel-forefoot overlap and 7.5 per cent. for the left heel-forefoot overlap in relation to the stance phase of the step. This is summarized in Tables I and II. In brief, the overlap between heel and forefoot was 24.5 per cent. and 22.1 per cent. longer with the right and the left street shoes than when the subjects walked in the duty shoes. Marked pronation was present in the former case and absent in the latter because the duty shoes were made to meet the requirements for balance of the foot in walking.

This evidence supports the statement made by Ellis in 1889: "Let the form of the boot-lasts correspond in shape to that of the *feet in action*. Then, as I believe, the foot may be clothed with every reasonable regard for function and elegance, and yet, attaining its highest development, be preserved in the fullness of strength and of beauty."

This opinion expressed at the ending of the nineteenth century reflected the statement recorded by John Cross in 1819: "It is to the muscles that the foot is indebted for its arch, as well as for the firmness of the step. It is from a deficiency of vigor in these muscles, that the foot ever becomes plain, and that the plain foot is so unfit for the journey."

SUMMARY

1. Pronation of the foot is defined in terms of the prevailing imbalance of the foot while walking.

2. This definition is made possible by electrobasographic records of gait.

3. Twenty-four girls were studied with reference to the influence of shoes on balance of the foot while walking. Pronation was present in each case when street shoes of conventional design were worn. It was absent when the subjects wore shoes made to provide for balance of foot function in the stance phase of the step.

4. In these records, prevailing pronation is revealed by the overlap in weight-bearing time on heel and forefoot.

5. Under the influence of conventional shoes, normal feet may pronate while walking. Pronation brings strain on the whole locomotor mechanism, not on the foot alone.

6. The same feet do not pronate when the subject walks in shoes made to meet the requirements for foot balance in the stance phase of walking.

7. Normal balance of function of the extrinsic muscles, which sup-

port the bones of the foot in a tendinous sling, is the mechanism essential for protection against pronation and resulting strain.

8. The treatment of pronation, therefore, requires that consideration be given to the foot and the leg as a unit. Only through shoes which provide balance for the foot in the stance phase of gait can we compensate for malalignment of the os calcis with the tibia and the common contractures expressed through the tendo achillis.

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TRIMALLEOLAR FRACTURES WITH DISLOCATION OF THE ASTRAGALUS

A Method of Reduction and Fixation *

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In trimalleolar fractures, when from one-fourth to two-thirds of the articular surface is involved in the fragment of the posterior malleolus, the reduction may be very simple, but the retention of the position is quite difficult because of the immediate recurrence of the deformity when traction is released. In such cases, the following method has been used, and in no case has it failed to maintain the reduction.

TECHNIQUE

After the usual preparation of the skin, a Steinmann pin is placed through the os calcis and the traction bow is applied. The operator then reduces the fracture by traction and manipulation, using the Steinmann pin as a lever. A leg plaster is applied from the toes to above the knee, incorporating the pin in the plaster. With the Steinmann pin the reduc-

Fig. 1

Case 1. Lateral view of the right ankle after second reduction.

Fig. 2

Case 1. Lateral view of the right ankle after reduction with a Steinmann pin.

* Read before the Associated Physicians of Long Island, October 22, 1935.

† Service of B. W. Seaman, M.D., and William L. Sneed, M.D.

Fig. 3

Case 3. Preoperative lateral view of the left ankle.

Fig. 4

Case 3. Postoperative lateral view of the left ankle.

tion is easily maintained until the plaster is set, when the traction bow is removed. The plaster is changed at the end of the third week and the pin is removed. Weight-bearing with the leg in plaster is begun at the end of the sixth week. Active motion and physiotherapy are begun at the end of the seventh week. The end result can be estimated in about four months from the date of injury. There is some permanent limitation of motion in almost all cases.

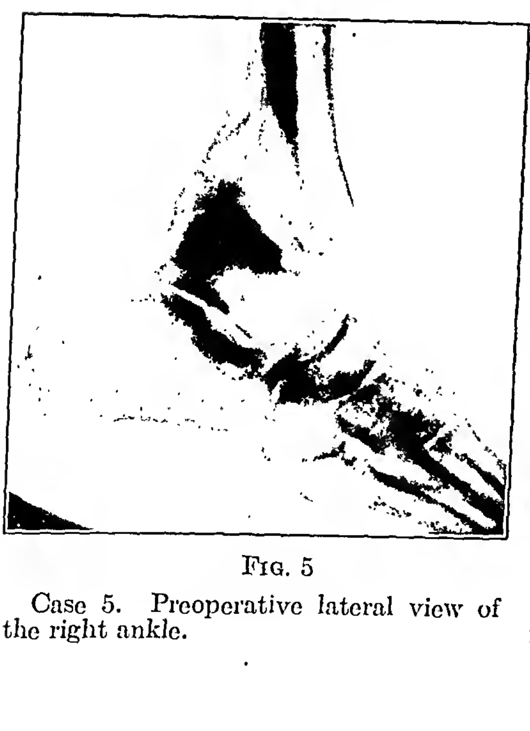

Fig. 5

Case 5. Preoperative lateral view of the right ankle.

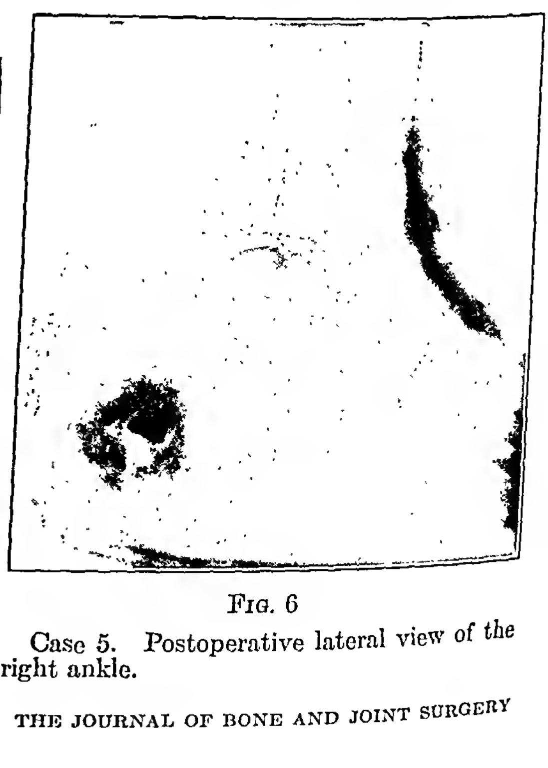

Fig. 6

Case 5. Postoperative lateral view of the right ankle.

CASE REPORTS

Case 1. J. W., white, male, aged thirty-nine, stepped into a hole and twisted his foot on August 26, 1932. Two attempts to reduce the fracture-dislocation were made before the patient was seen by the author on August 28, 1932. Another reduction was then done and the reduction was maintained according to the method described. Thirty-two months after the injury there was a complete range of motion in all directions.

This was the first case treated by this method.

Fig. 7-A

Fig. 7-B

Case 6. Preoperative anteroposterior and lateral views of the left ankle.

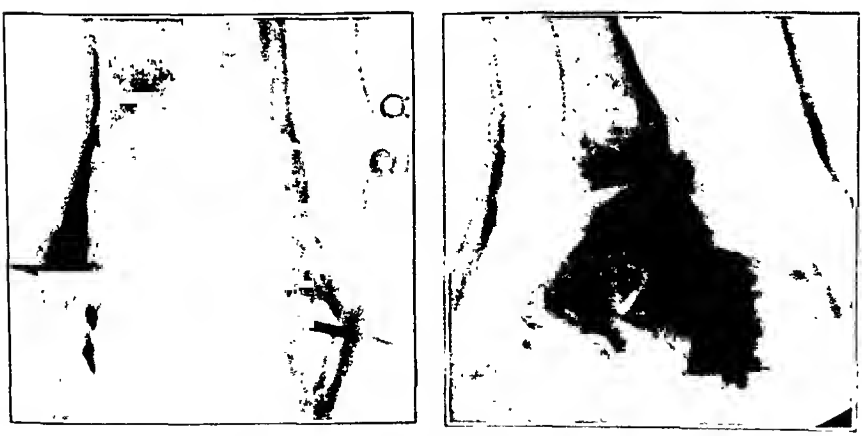

Fig. 8-A

Fig. 8-B

Case 6. Postoperative anteroposterior and lateral views of the left ankle.

CASE 2. D. E., white, female, aged thirty-five, was struck by an automobile on September 23, 1933. Eighteen months after reduction dorsiflexion, inversion, and eversion were normal. Plantar flexion was limited.

CASE 3. J. H., white, female, aged fifty-eight, a diabetic, fell on her ankle on August 4, 1933. Twenty-one months after reduction dorsiflexion, inversion, and eversion were normal and plantar flexion was limited by about 10 degrees.

CASE 4. C. R., white, female, aged fifty-nine, fell down some steps on December 26, 1934. Seven months after reduction there was some widening of the ankle with thickening of the synovia. Inversion, eversion, and dorsiflexion were normal. Plantar flexion was limited by 5 degrees.

CASE 5. J. K., white, female, aged thirty-five, fell on the ice on January 29, 1935. The fracture-dislocation was reduced by another physician without success. Reduction was obtained by the author and maintained by the use of the Steinmann pin. Eight months after reduction dorsiflexion, inversion, and eversion were normal. Plantar flexion was limited.

CASE 6. A. M., white, female, aged fifty-six, twisted her ankle and fell on it on March 8, 1935. Seven months after reduction complete dorsiflexion, inversion, and eversion were present. Plantar flexion was limited by 5 degrees.

CASE 7. J. O., white, female, aged forty-four, was knocked down by a wave on July 14, 1934. Three months after reduction dorsiflexion, inversion, and eversion were normal. Plantar flexion was limited by 5 degrees.

SUMMARY

In the case reports two cases have been included that involved less than one-third of the articular surface and could have been reduced without the pin.

This method of maintaining reduction of a trimalleolar fracture with a posterior dislocation of the astragalus has been used for three and one-half years with complete success in all cases. The method is simple and easily executed. No open reductions have been necessary, and no recurrence of the deformity has resulted.

PERITENDINITIS CREPITANS

A Muscle-Effort Syndrome

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The affection variously called "crepitating tenosynovitis", "traumatic tenosynovitis", and "crepitating peritendinitis" is not commonly met with in the private practice of medicine, but is well known among industrial surgeons. Although this condition has been recognized for over a century and responds promptly to immobilization treatment, little has been known of the real morbid picture underlying the disease. The outstanding diagnostic sign of crepitation in the soft tissues on movement of the extremity or part is so bizarre and so singularly confined in pathological states to this one group of conditions that one's curiosity concerning the underlying intrinsic causes is easily aroused but far less easily satisfied.

The usual history given by a patient is that, after a long lay-off from work or shortly after a change from habitual work to an unfamiliar task requiring new and rapid movements, he has experienced aching soreness in a particular muscle group. Continuation of the same work gives rise to severe pain which may call for immediate cessation of activity, or the pain on arising prevents the patient's return to work and brings him to the physician for relief. In other instances, the pain of direct trauma by contusion to the arm, leg, or fingers is superseded, after hours or days of continued usual and accustomed exertions, by the crippling pain of crepitating peritendinitis.

On first examination, the patient presents a localized swelling of the forearm or leg, often with oedema, if in the lower extremity, and frequently with local heat and redness of the part. There is severe pain on movements of the limb, marked in those active movements initiated by the particular muscle group involved or by the passive movements which place those same tendons and muscles under the most tension and on the stretch. By careful study of active and passive movements that produce pain, one can identify each tendon and muscle involved. During such active and passive movements, the examiner's hand, placed over the swollen area and site of tenderness, feels a distinct, and often startling, crackling crepitus. On auscultation with a stethoscope, one hears an astonishingly loud and confusing series of crackles, crunches, and squeaks. Occasionally the patient may have a slight fever; never in the author's experience has the temperature risen above 99.4.

The particular site of local swelling, redness, local heat, tenderness, and crepitation is situated along a tendon or group of tendons, most frequently at or near the musculotendinous junction and never, in the writ-

TABLE I

FREQUENCY OF INVOLVEMENT OF MUSCLES IN THIRTY-TWO † CASES OF PERITENDINITIS CREPITANS *

Muscle	Cases
Extensor carpi radialis longus	15
Extensor carpi radialis brevis	15
Abductor pollicis longus	15
Extensor pollicis brevis	15
Extensor indicis proprius	5
Extensor pollicis longus	5
Tibialis anterior	4
Extensor hallucis longus	4
Flexor carpi radialis	3
Extensor digitorum communis	3
Extensor digitorum longus	2
Gastrocnemius	2
Peroneus longus	1
Peroneus brevis	1

† Since compilation of this table, two unusual cases have been observed,—one of a young lady in whom there was crepitating myositis of the right supraspinatus muscle, and the other of an active middle-aged man in whom similar symptoms occurred in the right biceps femoris muscle.

* Associated muscles were often simultaneously affected.

er's experience, in that part of the tendon supplied with a synovial sheath. If the muscle possesses a synovial sheath, the sheath proper shows no distention or tenderness, and crepitation is lacking over this area as well.

Careful study of a series of thirty-two cases of crepitating peritendinitis personally observed showed that eighteen patients suffered no direct trauma to the part involved; fourteen of these had either renewed previous employment after long lay-offs from work or had been given unfamiliar tasks involving repeated and rapid movements of particular muscle groups. Fourteen patients received contusions upon hand, arm, or leg, and continued to work from one to fourteen additional days at usual and accustomed toil before becoming incapacitated by the development of crepitating peritendinitis. Each of these fourteen patients had definite and unmistakable evidence of direct trauma in the form of a bruise (several with marked ecchymosis), small laceration, or abrasion to the part, and there can be no doubt that direct injury occurred.

By far the most frequent muscle group affected was that composed of two radiocarpal extensors, with simultaneous involvement of the abductor pollicis longus and extensor pollicis brevis. Simultaneous involvement of these four muscles and their tendons occurred in fifteen instances. The distribution of muscles and tendons involved in the thirty-two cases is shown in Table I.

Several writers have attempted to show that the disease is a metastatic form of bacterial infection, or a toxic manifestation of focal infection,

or is due to a gouty or rheumatic diathesis. In only one of these thirty-two cases could a definite and undoubted infectious connection be proved. This patient developed a furuncle on the dorsum of the left hand. His temperature was 99.4 by mouth. Incision of the boil (the patient continued to work) was followed five days later by crepitations along the extensor tendons of the hand and of the index finger to the midjoint. Two patients had small lacerations at the site of direct trauma, which showed no sign of active infection. A fourth patient had small cement burns on the arm. Only one patient was found who had a recent cold and upper respiratory infection. He was malnourished and had very carious teeth. In all the other patients, no active focus of systemic infection could be found. There were three patients who had slight fever in whom no cause for fever could be found other than the crepitating peritendinitis. The fever subsided and did not persist after effective immobilization of the part.

Since adequate explanation of the pathological nature of this illness was lacking, three patients were so cooperative as to allow exploration and biopsy to be carried out under local anaesthesia. These three cases deserve report in detail.

CASE REPORTS

CASE 1. J. J. R., male, aged thirty-two, a tire worker, had been unemployed for almost two years. One week after beginning work, which consisted of changing and repairing automobile tires, he began to notice pain on motions of the left wrist and thumb. While at work early one morning he was forcibly struck by a tool on the left forearm. He continued work for about two hours when he was forced to stop because of pain on motions of the left thumb and wrist. He was unable to lift with this hand and complained of a feeling of loss of power.

Examination showed a swelling of the dorsoradial aspect of the left wrist, beginning four centimeters above the radial styloid process and running seven centimeters toward the elbow. Slight local heat and redness were present. The area described was extremely tender to pressure. Abduction and extension of the thumb, as well as flexion and extension of the wrist, produced pain and crepitation in the swollen area. The crepitation was felt by the patient and was both felt and heard by the examiner without the stethoscope. Through the stethoscope the friction rub was almost deafening in intensity. The patient had no fever and had had no recent colds or respiratory infections, and no systemic foci of infection could be found.

Under local anaesthesia (.0075 per cent. novocain), injected *intracutaneously* so as not to obscure any underlying tissue appearances, the skin and subcutaneous tissues were incised over the swelling. The subcutaneous tissues were very vascular, and many fine, briskly bleeding points were encountered. The deep fascia was transparent, tense, and bulging. At incision of the aponeurosis, translucent, gray, oedematous tissue bulged under considerable tension and was with difficulty identified as perimysial areolar tissue overlying the muscle. The muscle was dark and cyanotic in appearance. No fibrin was seen. The tendons of the extensor carpi radialis longus and of the extensor carpi radialis brevis were exposed radial to the thumb muscles by separating the thumb muscles by sharp dissection. The tendons of the extensor pollicis brevis and of the abductor pollicis longus took their origin from the deep surface of the muscle belly, while the radial extensors arose on the superficial surface of their muscles. Normally, between the two sets of tendons, areolar tissue interposes, but in this instance there was a clear, clean space free from fluid and gross fibrin. The tendons of the extensor pollicis brevis and of the

abductor pollicis longus lay upon and in contact with the radial extensors. At the lower border of this area, the reduplicated folds of tendon sheath, uninjected and containing no fluid, could be seen about the radial extensors. The tendons of the radiocarpal extensors were yellow and turgid, and showed tiny, fine, wavelike corrugations on their surface.

Voluntary motion of the thumb and of the carpal extensors was present, and the palpating finger detected intensive crepitation transmitted through muscle belly and tendon. No bleeding was encountered beneath the deep fascia; the perimysium and peritenon contained fine vessels. When tissues from over the muscle-tendon junction were removed, no bleeding occurred. Cultures of the wound were sterile.

Paraffin sections revealed extreme oedema with spreading apart of fibers of connective tissue, fibrillation of elastic fibers, small areas of interstitial hemorrhage, and red static thrombosis of the venules. Small arterioles showed margination by leukocytes. There were scattered areas of plasma-cell and round-cell infiltration. Interstitial deposits of fibrin were found in granular form, as well as in clumps and in masses.

CASE 2. F. S., male, aged forty, a laborer, had been employed steadily for over a year. Four days before reporting for treatment he had begun to use a single jack hammer for breaking concrete with a cold chisel. Following two days of this work, the right forearm had become sore. The patient continued at his work part of the time, using the air-compression hammer the last day and a half. Increasing pain and difficulty in using the right hand and wrist forced him to stop work in the middle of the afternoon. He denied direct injury by blow or by strain. There was no history of recent colds or of upper respiratory infection.

Examination showed a ruddy-cheeked, well-developed Swedish laborer, whose right lower forearm was swollen on the dorsoradial aspect. Local heat and marked tenderness were noted, but there was no redness of the area. The swelling began five centimeters above the radial styloid process and extended to twelve centimeters from the wrist. Movements of the thumb and wrist, passive or active, evoked extreme pain, and gross crepitation could be felt by the examining hand and heard with the stethoscope. Active dorsiflexion of the wrist and extension and abduction of the thumb against resistance were painful, and these movements were markedly diminished in strength as well. If the thumb was held rigid, movements of the distal phalanx were painless. The patient's temperature was 99.4. No foci of infection were found on careful examination.

Exploratory operation was carried out after intradermal infiltration of 1-per-cent. novocain without adrenalin. The subcutaneous tissues contained many fine, briskly bleeding vessels. On incision of the deep fascia, the underlying tissues bulged out under the tension of the translucent oedematous tissue, so transparent that one could see tiny vessels coursing through the jellylike oedematous tissue to the depth of over one-half an inch. In most of these vessels, the blood could not be stripped along with the handle of the scalpel. The tissues oozed a clear, slightly straw-tinged fluid. The muscle near the tendon junction of the abductor pollicis longus and the extensor pollicis brevis was soggy, oedematous, and dark purplish-red in color. The abductor muscle retained the finger impression and scarcely any voluntary contraction was present. This muscle did not contract when a small piece was excised for biopsy. The short thumb extensor had a greater power of voluntary contraction and contracted sluggishly when its fibers were cut. Careful sharp dissection separated the muscle bellies and, on retraction, one could see their tendons arising on the deep surface of the muscle. Beneath this muscle was a free space unlined by synovia. The floor was formed by the radiocarpal extensor tendons which arise on the superficial surface of their muscles. The tendon surfaces were stained yellow and showed tiny, fine, wavelike corrugations on their surfaces, apparently either fibrin deposits or areolar-tissue strands. Near the distal lower depths of the wound one could see the reduplicated folds of synovial sheaths which were not tense or bulging with fluid.

Specimens for biopsy were taken of the oedematous areolar tissue of the peritenon and perimysium above and beneath the thumb muscles and from the bellies of the two thumb muscles themselves. These four specimens were placed in separate tubes of ster-

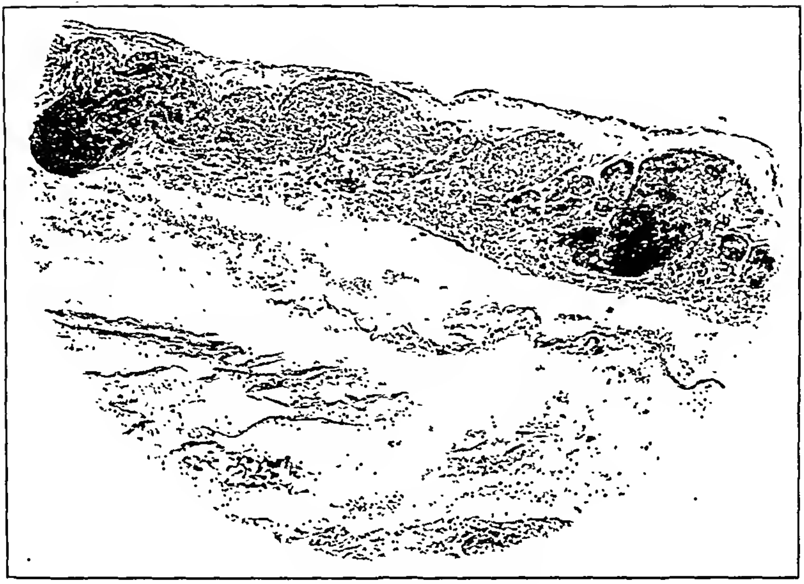

Fig. 1

Low-power photomicrograph (× 80). Hematoxylin-eosin stain. Thrombosis of the venules in the peritenon and perimysium with oedema of the surrounding areolar tissue. Extravasations of red blood cells can be seen in the lower portion of the specimen.

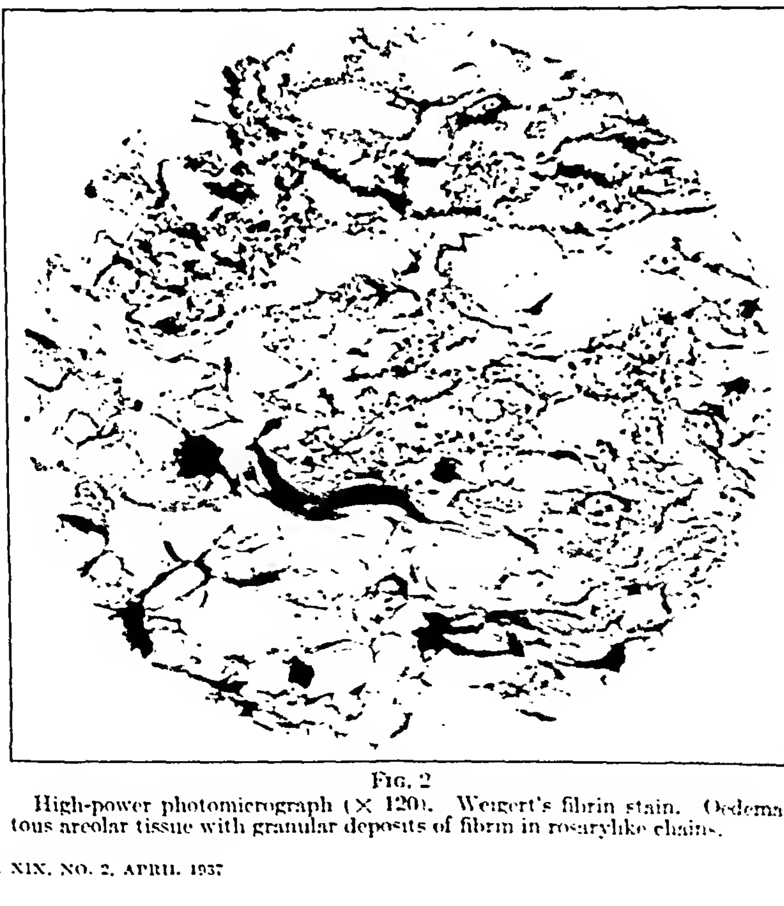

Fig. 2

High-power photomicrograph (× 120). Weigert's fibrin stain. Oedematous areolar tissue with granular deposits of fibrin in rosarylike chains.

FIG. 3

Photomicrograph (× 80). Weigert's fibrin stain. Solid clumps of interstitial deposits of fibrin in the oedematous areolar tissue about the muscle.

ile cold normal saline, covered with sterile mineral oil, and taken to the laboratory for study of hydrogen-ion concentration and for miscroscopic section. With the help and kindness of Dr. Maurice Tainter of the Department of Pharmacology of the Stanford University Medical School, the writer is able to report the figures obtained.

With the use of the Michaelis series, standard colorimeter set for determination of the hydrogen-ion concentration and with paranitrophenol as the final indicator, the following pH values * were secured: abductor pollicis longus, 6.55; extensor pollicis brevis, 6.38; peritenon and perimysium superficial to the muscle-tendon junction, 6.30; similar tissue beneath the muscle-tendon junction, 6.30.

The tissues were immediately placed in 95-per-cent. alcohol, and paraffin sections were prepared from the fixed tissue and stained with special stains. The saline extracts remaining were positive for lactic acid with the ferric-chloride test. Cultures of the wound itself showed no pathogenic bacteria.

Microscopic sections stained for glycogen failed to show glycogen in the muscle substance of the abductor pollicis longus, while the extensor pollieis brevis showed small quantities infrequently collected between the sarcolemma and the sarcoplasm in the better preserved muscle areas. Sections were further stained with hematoxylin-eosin, van Gieson's stain, phosphotungstic acid, Mallory's stain, and Weigert's fibrin stain. The muscle fibers showed fragmentation in many places. The fibers of the abductor muscles had lost their cross striations and were swollen and hyaline, with frequent splitting apart of sarcostyles, and with occasional liquefactive necrosis. Everywhere the sarcoplasm was separated from the sheath by oedema. Both hemorrhage and fibrin deposits were seen in the oedematous endomysial fibrous tissue. Local areas of static thrombosis of venules, with infrequent sparse round-cell and plasma-cell infiltration were seen in the endomysium. In the oedematous areolar tissue of the peritenon and perimysium were red thrombi and deposits of fibrin in granular form as well as in large clumps and in masses.

* The errors and difficulties encountered in accurately estimating tissue pH values by the colorimetric method are well known. Glass-electrode intravital pH readings would be of great value in checking the reliability of these colorimetric findings.

Case 3. S. L., male, aged twenty-one, who had been unemployed for over a year, began stacking crates of empty beer bottles in a warehouse. He stood on the floor tossing crates to the workman above, who piled and stacked. The work was fast and lasted only two days. On the afternoon of the second day, he noticed pain, swelling, and a creaking sensation over the lower left forearm. There was no history of a direct blow or of a bruise. No further work was available, but the left forearm continued to be sore and tender. Five days later he reported to the Out-Patient Clinic of the Lane Hospital. There was no history of a recent cold or of infection.

At physical examination the temperature was found to be normal. There was a fusiform swelling over the dorsoradial distal one-fourth of the left forearm. The swelling began five centimeters above the radial styloid process and reached its maximum nine centimeters above the styloid process. There was no local heat, but the skin was slightly reddened. The area was tender to pressure and, on movements of the wrist or thumb, crepitation could be felt with the hand, and loud crackles and crunching sounds were heard through the stethoscope. Radial dorsiflexion against resistance and active abduction or extension of the thumb gave rise to the greatest pain. No foci of infection could be found. The patient gave a history of a similar condition in the anterior shin muscles of both legs during training for track in four successive years in high school and in junior college.

An exploratory incision was carried out after the skin had been anaesthetized with intracutaneous injection of 1-per-cent. novocain. The subcutaneous vessels bled briskly

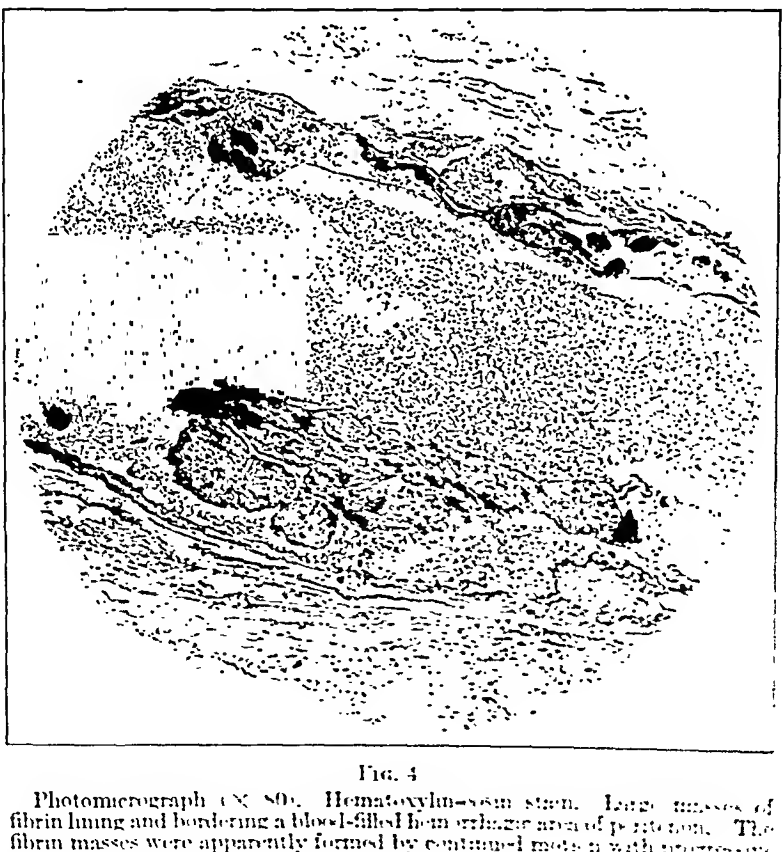

Fig. 4

Photomicrograph (× 80). Hematoxylin-eosin stain. Large masses of fibrin lining and bordering a blood-filled hemorrhagic area of peritenon. The fibrin masses were apparently formed by continued motion with progressive agglomeration of finer fibrin clumps and granules.

at many fine points. The deep fascia was tense and transparent and when it was excised the underlying tissues bulged into the wound. The overlying perimysium was oedematous, clear, and jellylike and oozed a faint straw-tinged fluid. Fine blood vessels could be seen coursing through the transparent tissue and the blood could be stripped along the vessels with difficulty. Both the abductor pollicis longus and the extensor pollicis brevis contracted voluntarily. In color, they were dark red, bordering on a purplish tint. When voluntary or passive movements of the thumb or of the wrist were made, very distinct crepitation could be felt in the muscle and only faintly in the tendon. The muscle bellies were carefully separated and, on elevation and retraction, their tendons were seen to arise on the deep surface of the muscle. Between the thumb muscles and the underlying radiocarpal extensor tendons was oedematous areolar tissue of peritenon, through which could be seen the yellow-tinged tendons. The muscle at the tendon junction of the radiocarpal extensors was dark and oedematous, and the tendons arose on the superficial surface of the muscle.

Cultures of the wound depth were sterile. Specimens for biopsy were taken of the two thumb muscles, which contracted briskly when cut, and of the perimysium superficial to the muscle and peritenon beneath. These were separately placed in cold sterile normal saline, covered with oil, and taken to the laboratory, and the hydrogen-ion concentration was determined in the same manner as before, using paranitrophenol as the indicator. The estimated pH of the abductor pollicis longus was 6.0; of the extensor pollicis brevis, 5.9; of the tissue above the muscle, 5.9; and of the tissue beneath the muscle, 6.0.

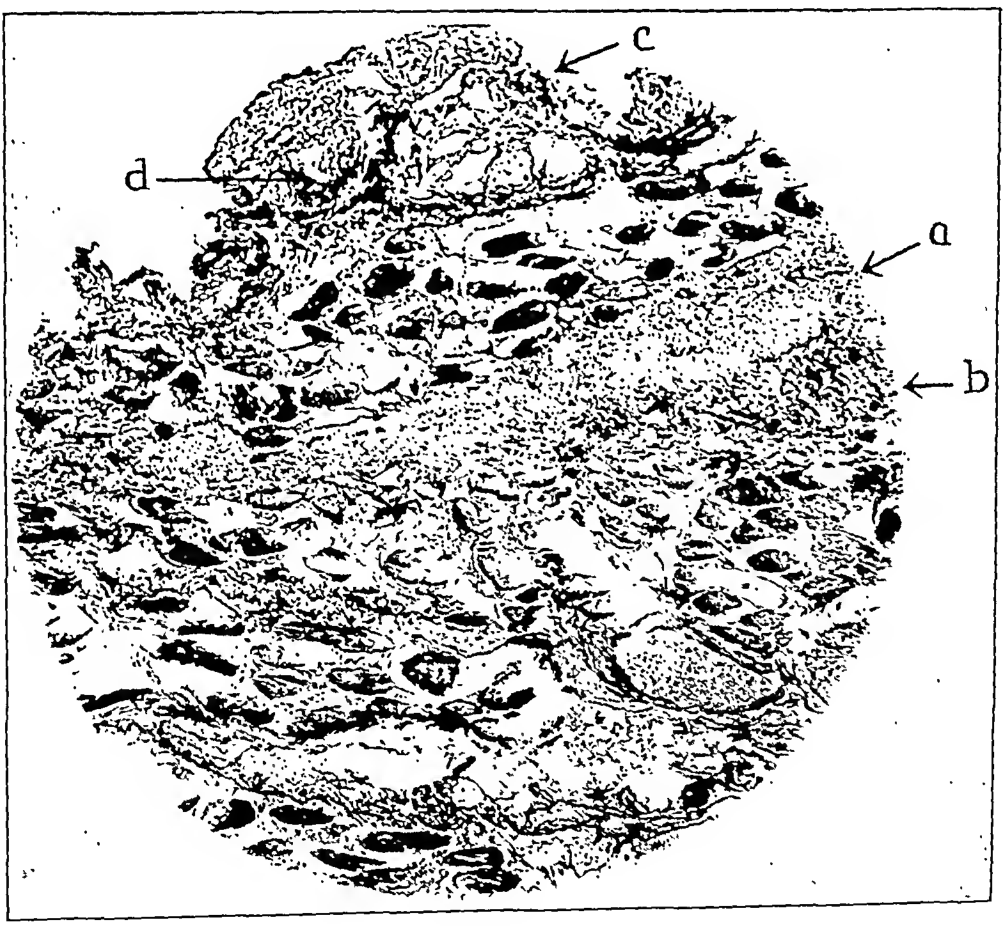

FIG. 5

Photomicrograph (× 80). Mallory's stain. Interstitial hemorrhage of endomysium (*a*). Marked oedema with clear halo separating sarcoplasm from sarcolemma about individual muscle fibers. Liquefactive degeneration and necrosis of muscle fibers present. Fibrin deposits at *b*, *c*, and *d*.

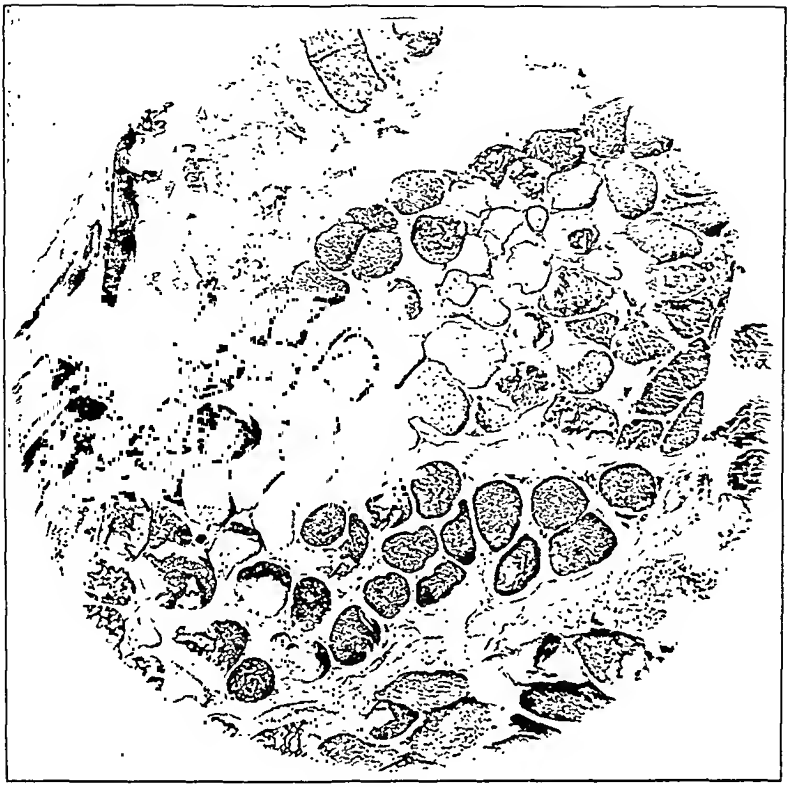

Fig. 6
Photomicrograph (× 80). Hematoxylin-eosin stain. Oedema of endomysium. Liquefactive necrosis of muscle fibers.

Again the residual saline extract was positive for lactic acid when tested with ferric chloride.

Microscopic paraffin sections showed that the muscle glycogen was depleted. Only small crescents between the sarcoplasm and the sheath still stained for glycogen. The muscle fibers were fibrillated, the cross striation was often lost, and many areas showed liquefaction of muscle fibers, although the sheath remained. Many small red and hyaline thrombi were seen in the endomysial fibrous tissue. Frequent cross fracture of muscle fibers with retraction of the fiber in the sheath could be made out. Frequently, the sarcostyles of the muscle fiber could be seen split apart and fibrillated. The sheath was frequently separated from the sarcoplasm by oedema. There were focal hemorrhages in the muscle bundles, with areas of fibrin deposit between the fibrous tissue spread apart by hemorrhage. The perimysium showed venous sinusoids occluded by red and hyaline thrombi. Marked oedema split apart the structure of the fibrous tissue and focal small and large hemorrhagic areas were seen. Fibrin deposits in clumps, in granular form, and in larger masses could be made out. Scattered infiltration of plasma cells, of round cells, and of clasmatocytes were seen.

DISCUSSION

These operative and laboratory findings are significant. The gross appearance of the tissues on operative exposure is as unusual as the crepitation on clinical examination of the part. These facts (*i.e.*, clear jellylike oedema of the areolar tissue about muscle and tendon, dark-

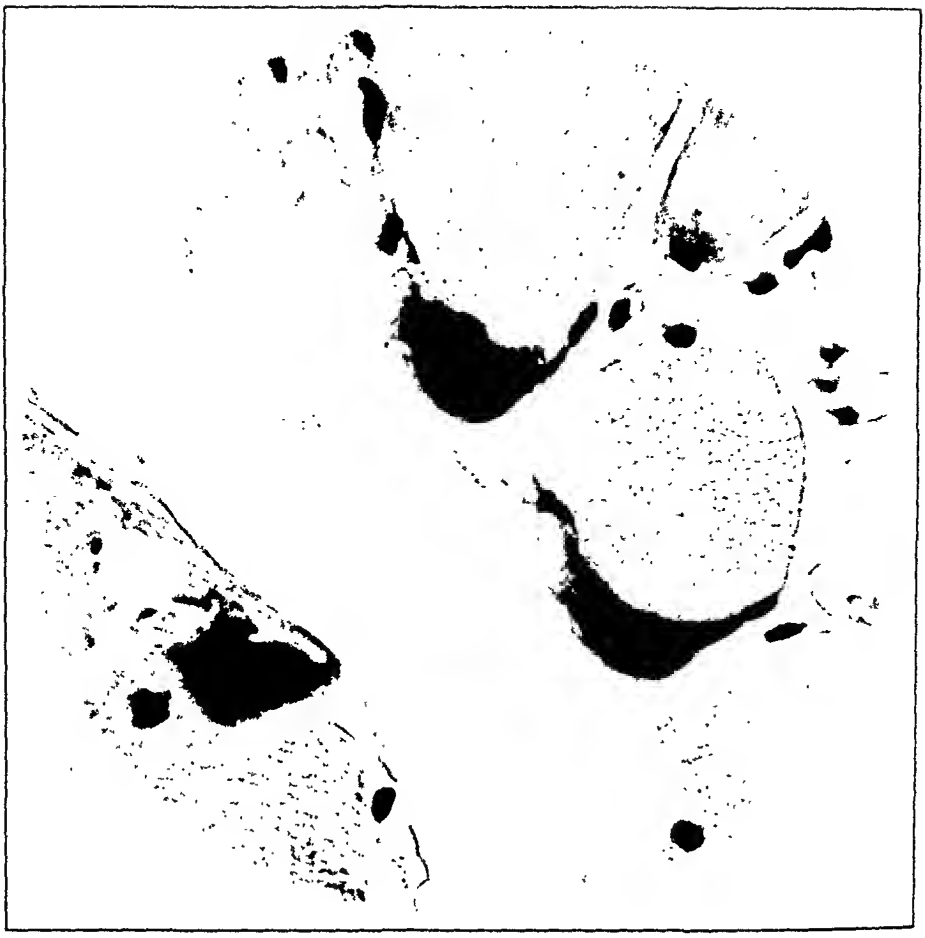

FIG. 7

Photomicrograph (× 220). Best's carmine stain for glycogen. Oedema of muscle and endomysium. About the better preserved muscle are crescents of fluid between the sarcolemma and the sarcoplasm, which takes glycogen stain.

colored muscle which may be lacking in voluntary contractile power and, on histological examination, shows muscle-fiber lysis or destruction, hemorrhage interstitially in muscle and areolar tissue, thrombosis of venules and interstitial fibrin deposit, loss of muscle glycogen, and the relatively acid pH value found in the tissues, extracts of which are positive for lactic acid) all bear out the clinical impression that the condition arises through fatigue and exhaustion of definite muscle groups rather than through metastatic bacillary inflammation from foci of infection or from vague and shadowy "toxic conditions". In every one of the thirty-two cases, excessive and unusual activity or usual activity following direct trauma had taken place.

While only three patients were subjected to operation, the site and distribution of swelling, of tenderness, and of crepitation never coincided with the extent and boundaries of normal tendon sheaths. In the patients upon whom operations were performed the tendon sheaths were seen to be uninvolved and beyond the pathologically changed area.

Since Velpeau first described tenosynovitis sicca in 1818, the condition has been ascribed to overexertion and to the fatigue resulting from

unaccustomed work. Boyer stated that the condition was not a "synovitis sicca", since the swelling, tenderness, and crepitation lay outside of the tendon sheaths, and gave it the name of "*cellulite peritendineuse*". Almost without exception, the standard text-books and the hand-books of surgery still refer to the disease as a tenosynovitis. It was not until 1909 that von Frisch took specimens for biopsy from tissue about the tendons of the thumb muscles in two cases. He noted the serous oedema and marked congestion of the blood vessels of the peritendinous areolar tissue and found the tendons unchanged grossly. Troell, in 1918, reported a carefully studied series of cases and took pains to reproduce outline drawings of the anatomical extent of tenderness, swelling, and crepitation, which showed them invariably to be beyond the area of synovial sheaths. In addition, he cited instances, as did Velpeau, of the involvement of muscles and tendons which normally have no sheaths. The tendo achillis, the triceps brachii, the pronator teres, the vastus lateralis, and the rhomboidei have all been described as sites of this disorder. Troell, from his clinical studies and from the biopsies reported by von Frisch, established the name "peritendinitis crepitans". Hauck added a further instance of biopsy in a single case involving the tendons of the dorsal thumb muscles.

The experimental approach has been applied to this disease by Oblenskaja and Goljanitzki, who observed 189 cases of serous tenosynovitis among 700 tea packers in a Moscow tea factory over a period of eight months. These workers make between 7,500 and 12,000 estimated movements of the hands a day. In the experimental work done by these authors, enforced alternate movements of extension and of flexion of the hind leg of a rabbit were carried out by means of an electric motor at the rate of 18,000 to the hour. In one hour no change was observed, but in two hours oedema of the peritendinous and perimuscular tissues was present, while in six hours the tendon sheaths and joint cavities were full of fluid. Histological examination was not reported, and crepitations were not described. Moritsch and Blau used exhaustion through faradization over the tendo achillis of the rabbit to study the problem. Two rabbits, faradized in this manner for ten minutes daily for one month, showed no gross changes in the tendons of the hind legs. With previous doses of typhoid vaccine, daily faradization of the tendo achillis for six days gave rise to adhesive inflammation between the skin, the peritendinous tissues, and the surrounding tendons and muscles. Similar experiments, using intravenous injections of virulent streptococci, followed by faradization, produced similar changes. No crepitus was felt or heard and no microscopic studies were carried out. These authors felt that peritendinitis crepitans is a metastatic manifestation of a chronic focal infection, of rheumatism, or of acute upper respiratory infections, the site of metastasis being determined by trauma.

From the present studies, it is evident that the primary pathological change is probably in the muscle, through exhaustion by continued and

unremitting unaccustomed toil, in which use is made of a particular muscle group with friction of tendon on tendon, unprotected by synovial sheath or by bursae overlying bony prominences, and, by direct external trauma to the part, thrombosis of blood vessels of the peritenon and of the perimysium occurs. Whether lactic-acid retention precedes thrombosis of venules is not known. At all events, with thrombosis of venules, lactic-acid retention occurs, oedema appears, hemorrhage in areolar tissue and muscle takes place, fibrin is deposited in the oedematous tissues, and crepitation clinically appears. Exhaustion of the muscle is accompanied by depletion of muscle glycogen, and, in the advanced cases, liquefactive changes appear; in the less advanced cases, fibrillation and fracture of muscle sarcoplasm can be seen, as well as loss of cross striation, hyaline changes, and oedema.

Finally, if one can by this means show acute gross and microscopic changes through exertion of internal muscle forces alone, what rôle may we attribute to the constant and repeated unremitting minor traumatic and mechanical insults of body motion and exercise in the degenerative diseases of the locomotor apparatus of the body? Meyer has already pointed the way in his careful studies of attritional changes in human joints, of the tendon of the long head of the biceps brachii, of the supraspinatus tendon, and of the phenomena called by him "polishing of bony surfaces".

TREATMENT

Treatment has not been improved upon since Velpeau advised rest and immobilization of the part, using a starched crinoline bandage for this purpose. All too common an error is the use of a splint which ineffectively immobilizes the muscles and tendons involved. The failure to include the thumb in cases of involvement of the forearm is a frequent mistake. Immediate relief is obtained by the use of an effective unpadded plaster splint, and in those cases in which there is slight fever the temperature returns to normal. The thirty-two patients whose cases are reported in this study averaged ten and one-half days' disability. In two instances, insufficient immobilization prolonged the disability to twenty-two and thirty days. The various forms of heat, massage, and motion bring no relief and have no place in the treatment of this affliction; they serve only to prolong disability. Elastic compression or adhesive strapping is useless except in the mildest cases. It is highly important to recognize and to practice as well as to teach these concepts, since every standard text-book and system of surgery in the English language, as well as most of those published in German, advise rest, but with massage and early motion, as well as the application of heat in its various forms.

CONCLUSIONS

1. Peritendinitis crepitans is the result of exhaustion of particular muscle groups by unaccustomed and unremitting toil, or by continued, usual, accustomed labor following direct trauma.

2. Pathologically it is characterized by glycogen depletion of muscle, acute degenerative muscle changes, thrombosis of venules, retention of lactic acid, oedema, and local increase in pH to a relatively high acid reaction. Interstitial deposits of masses and of clumps of fibrin give rise to the distinct diagnostic clinical sign of crepitation in the soft parts involved.

3. The primary change is without doubt in the muscle, the other factors developing secondary to muscle exhaustion.

4. The disease is not connected with the synovial tendon sheaths, and is not a "synovitis sicca".

5. Adequate, complete immobilization of joints and portions of the extremity moved by the affected muscles and tendons is the logical and most effective treatment. Baking, heat, massage, elastic compression, or strapping are makeshifts and are utilized without a true understanding of the pathological changes existing.

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AVULSION FRACTURE OF THE TIBIAL ATTACHMENTS OF THE CRUCIAL LIGAMENTS

Treatment by Operative Reduction

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A critical analysis of the generally accepted methods of treating avulsion fractures of the tibial attachments of the crucial ligaments shows clearly their impracticability. Reduction cannot be accomplished by such treatment as manipulating the leg into extension and immobilizing it in this position, since in extension the anterior crucial ligament is taut and hence lifts the fragment from its tibial bed. The alternative method of removing the broken fragment operatively is likewise unsatisfactory, in that it leaves the crucial ligament at loose ends, with consequent impairment of the stability of the knee joint.

Although for many years sporadic articles have appeared in the literature calling attention to the futility of the generally recognized treatment, but little progress has been made in developing a satisfactory method of reduction. Attempts on the part of the writer to devise a method that would insure reduction and retention of the fragment have led to the evolvement of the operative technique to be described. The method is proving practicable and has given consistently good results in a small series of cases.

OPERATIVE TECHNIQUE OF REDUCTION OF AVULSION FRACTURES OF THE ATTACHMENT OF THE ANTERIOR CRUCIAL LIGAMENT

Figure 1 shows a typical avulsion fracture of the attachment of the anterior crucial ligament. In reducing this fracture, the knee is flexed at a right angle and an Esmarch bandage is applied to the upper leg.

An incision is then made over the inner aspect of the knee joint. It begins at a point corresponding to the attachment of the vastus muscle to the quadriceps tendon, curves around the patella about one-half an inch away from it, runs along the inner margin of the patellar tendon, and terminates one inch below the attachment of the patellar tendon. The fascia and synovia are incised. The patella is displaced outward.

The periosteum on the medial aspect of the tibia is separated for a distance of one inch below the margin of the tibia and is retracted. Curettage of the blood clot in the cavity left by the fragment is carefully carried out.

Both menisci are carefully inspected. If damaged, they are removed in their entirety. Special instruments (Fig. 2) are used for this purpose, which make it possible to follow around the condyles of the tuberosities

of the tibia and to free the cartilages without damage to the joint surfaces.

Two drill holes are made from the anterior surface of the tibia to the fracture cavity, beginning medial to the attachment of the patellar tendon and three-quarters of an inch below the margin of the tibia. These drill holes may converge slightly at the lower end to facilitate tying the suture knot. The drills should emerge at the edges of the fragment, or slightly to the outside of the edges, so that when the fragment is pulled into its bed it will not be held up by the suture.

If the fragment is of sufficient size and comes far enough forward, a drill hole may be made through it, but care must be taken to avoid splitting the fragment.

All bone dust should be carefully removed from the drilled areas.

A double suture is passed through one drill hole in the tibia; it is then drawn through the drill hole in the fragment, or, in the absence of this channel, through the anterior crucial ligament at its attachment into the bone; and it is finally brought down through the other drill hole in the tibia to the outside where it is tied. (See Figure 3.)

If, upon reduction, the crucial ligament is found to be unusually lax, it may be tightened by moving the frag-

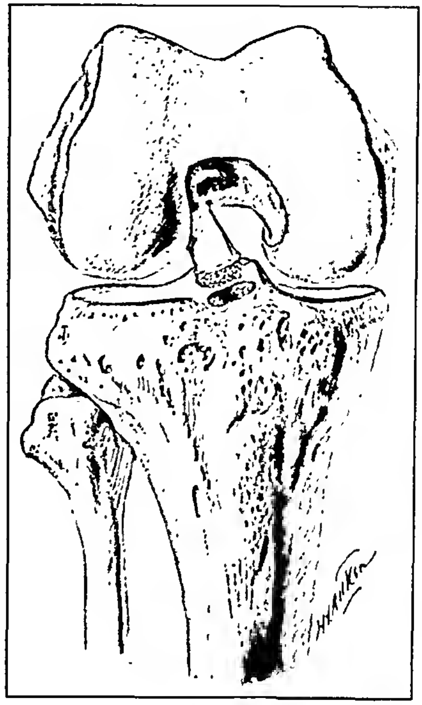

Fig. 1

Avulsion fracture of the attachment of the anterior crucial ligament.

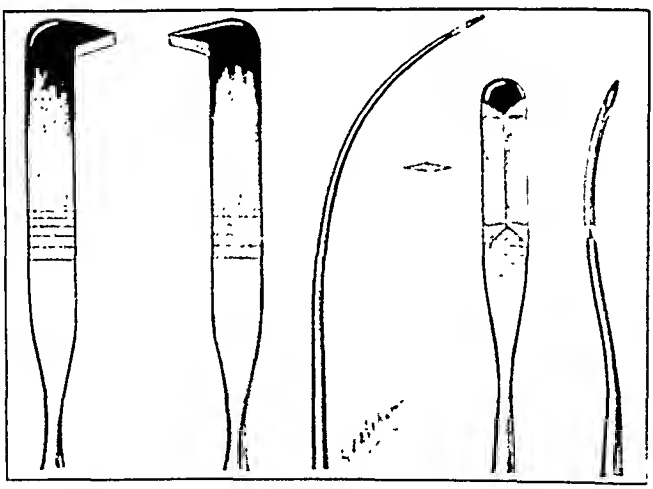

Fig. 2

Special instruments used to facilitate the removal of the menisci. The hooked instrument makes freeing of the cartilage easy, and the instrument with the double cutting edges permits freeing of the cartilage at its posterior attachment without damage to the joint surfaces.

Fig. 3

Operative reduction of an avulsion fracture of the attachment of the anterior crucial ligament.

ment forward. This is made possible by shaving the edges of the cavity to enlarge it anteriorly.

The wound is closed in the usual manner.

Special attention should be given to the bandaging after operation in order to obtain the maximum amount of compression. Sheet wadding, one and one-half inches thick, is first applied and then compression is obtained with a flannel bandage. The Esmarch bandage is removed.

A posterior plaster-of-Paris shell is applied with the knee in about 25 degrees of flexion. Immobilization is continued for from five to six weeks. Baking, massage, and passive movements are then carried out, care being taken to force complete extension, which is the last motion to return.

CASE REPORTS

Case 1. W. B., male, aged fifteen years, injured the right knee in a fall from a bicycle.

Roentgenographic examination showed a fracture of the spinous attachment of the anterior crucial ligament extending into the inner tubercle. The fragment was of the large size usually seen in these fractures in children and showed a tendency to displace laterally. There also appeared to be a crack through the fragment posteriorly. (See Figures 4-A and 4-B.)

Operative reduction, according to the technique described, was carried out six days after the injury. Damage to the external meniscus necessitated its removal.

End Result: One year after the operation, the knee is painless, stable, and has a full range of motion.

Case 2. R. W., male, aged ten years, injured the right knee in a fall from a horse.

Roentgenographic examination showed a fracture of the anterior tubercle of the tibial spine. The fragment was long and narrow and hinged posteriorly. (See Figure 5.)

Operative reduction, according to the technique described, was carried out two days after the injury.

End Result: Two and a half years after the operation the knee is painless, stable, and has a full range of motion. (See Figures 6-A and 6-B.)

Case 3. Mrs. H. W., aged thirty-seven years, injured the right knee in a fall. The knee locked in about 20 degrees of flexion. For two weeks the patient did not consult a physician and continued to limp about on the leg.

Roentgenographic examination, which was first made two weeks after the injury, showed a fracture of the anterior tubercle of the tibial spine. Arthritic changes were present around the inner condyle of the femur.

Operative reduction was immediately carried out according to the technique de-

scribed. When the joint was opened, an area was seen on the inner condyle of the femur where the cartilage was worn away, apparently from arthritic irritation.

End Result: Four and a half years after the operation the knee is stable, painless, and has complete function. There is, however, some catching in the joint, and the roentgenogram (Fig. 7) shows marked ridging on the margin of the femoral condyle, which is the result of the irritative arthritic process and possibly of damage to the condyle at the time of injury. As yet, the patient has not suffered from these changes.

CASE 4. J. S., male, aged forty-five years, was hit on the knee by an automobile. Roentgenographic examination revealed a large fragment, with the anterior crucial ligament attached, lying between the condyles. It had been torn from the internal tibial spine.

Operative reduction, according to the technique described, was carried out three days after the injury.

End Result: One year and three months after the operation, the knee is stable, painless, and has complete function.

OPERATIVE TECHNIQUE OF REDUCTION OF AVULSION FRACTURES OF THE ATTACHMENT OF THE POSTERIOR CRUCIAL LIGAMENT

Figure 8 shows a typical avulsion fracture of the attachment of the posterior crucial ligament. During the reduction of this fracture, the patient lies on his face with the leg extended. No tourniquet is applied.

An incision is made over the popliteal space, in the midline. By separation of the gastrocnemius at its point of bifurcation, excellent

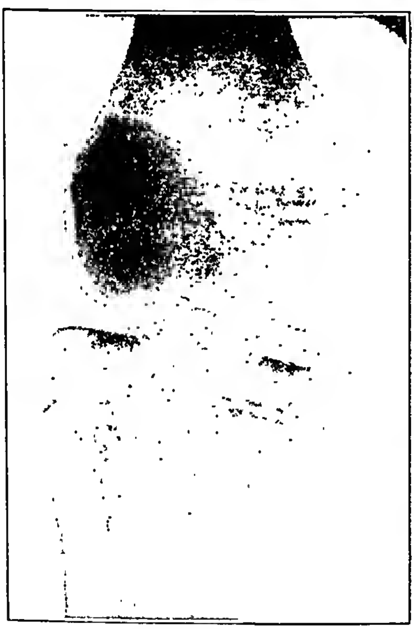

FIG. 4-A

Case 1. Anteroposterior roentgenogram before operation, showing fracture extending into the inner tubercle of the tibial spine and a crack through the fragment posteriorly, with deviation of the fragment to the outer side.

FIG. 4-B

Case 1. Lateral roentgenogram before operation. Note the large size of the fragment and the displacement caused by the attachment of the crucial ligament when the knee is in 15 degrees of flexion.

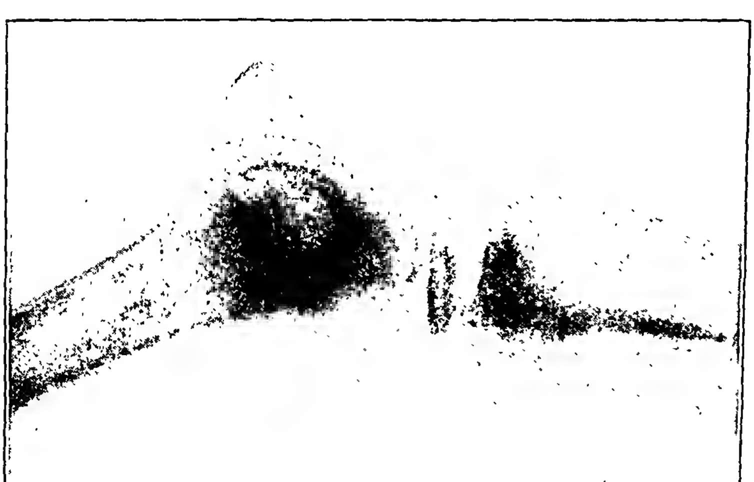

FIG. 5

Case 2. Lateral roentgenogram before operative reduction, showing the long, narrow fragment, hinged posteriorly.

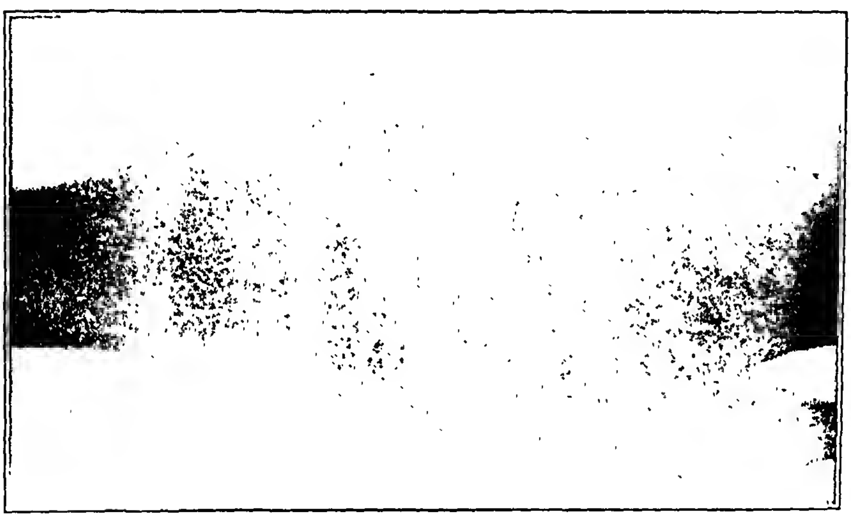

FIG. 6-A

Case 2. Anteroposterior roentgenogram taken two and one-half years after reduction.

FIG. 6-B

Lateral roentgenogram taken two and one-half years after reduction.

exposure is obtained. The artery, veins, and nerves are retracted laterally.

In the two cases treated by the writer a hole was found in the posterior capsule of the joint, through which the fragment was visible and palpable.

A suture is passed through the ligament above the small bony fragment, and the fragment is pulled down to as near its original site as possible. The suture is attached to the capsular tissue, which is thick in this area.

The defect in the capsular tissue is repaired. The wound is closed tightly.

A plaster-of-Paris dressing is applied with the knee in 15 degrees of flexion, a position that relieves the tension posteriorly and thereby permits better healing of the skin.

At the end of four weeks, passive motion is begun. By the time that the position of full flexion is obtained, the attachment of the crucial ligament is sufficiently solid to allow weight-bearing. Recovery is usually complete within six weeks.

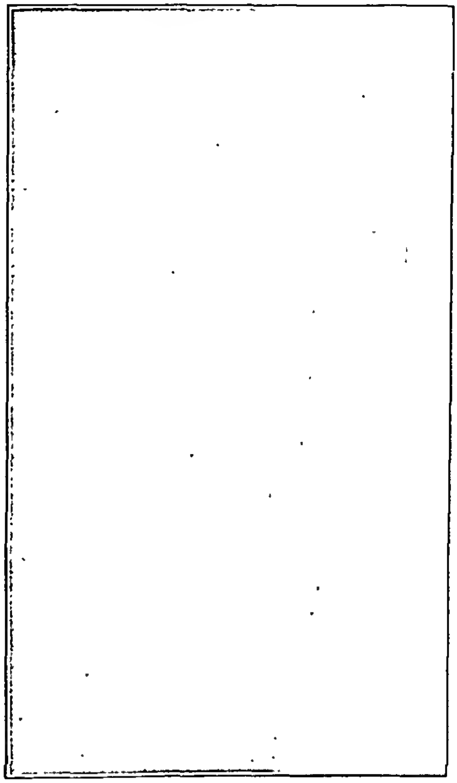

FIG. 7

Case 3. Lateral roentgenogram taken four and one-half years after operative reduction, showing the attachment of the crucial ligament in position. Irritative changes in the femoral condyle are due to damage at the time of injury and to an arthritic process.

CASE REPORTS

CASE 5. Mrs. R. C., aged sixteen years, was sitting in an automobile when it was struck head on by another car. The patient was hurled through the side of the car and landed against the truck before falling to the ground. The force of the impact was taken on the upper tibia, as evidenced by a contusion.

Physical examination showed no lateral instability, but posterior laxity was present to the extent that the tibia could be displaced three-quarters of an inch. Roentgenographic examination (Fig. 9) revealed a fracture on the posterior aspect of the tibia.

Operative reduction, according to the technique described, was carried out four days after the injury.

End Result: Seven years after the operation, the knee is absolutely stable. The range of motion is normal. The scar is not adherent. (See Figure 10.)

CASE 6. C. M., male, aged twenty-three years, was cranking a truck that was in gear, with his heels braced against the sill of the garage, when the truck jumped forward and bumped the tibiae several times. The truck finally stalled and its bumper pinned

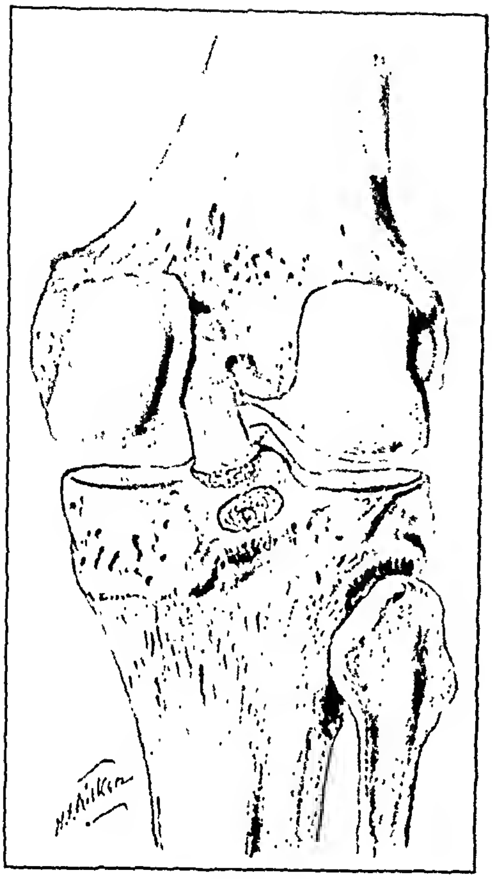

FIG. 8

An avulsion fracture of the tibial attachment of the posterior crucial ligament.

the patient against the garage for three and a half hours before he was rescued.

Physical examination of the right leg revealed that, with the knee fully extended, there was laxity which allowed 15 degrees of knock-knee and approximately three-quarters of an inch of posterior subluxation of the tibia. The leg was most comfortable in extension.

Roentgenographic examination showed an avulsion fracture at the tibial attachment of the posterior crucial ligament with separation of the fragment.

Operative reduction, according to the technique described, was carried out seven days after the accident.

End Result: Five months after the operation, the knee is stable, painless, and has a full range of motion.

DISCUSSION OF LITERATURE ON OPERATIVE REDUCTION

Pringle, in 1907, was the first to suture the tibial spine to the tibia after its avulsion and he published one case in which the result was successful. Following this report, isolated cases of suture of the fragment appeared in the literature (Christopher; Leriche and de Girardier; Simon; and Roth). Several writers (Moorhead; Swett, McPherson, and Pike; Costa; Courty; Goetjes; Matti; Caan; and Allen), without reporting cases, commented on the impracticability of the accepted methods. In all these methods, with the exception of those of Simon and Caan, the manner of suturing the fragment may be questioned. Screws and nails were used in a few instances, thereby introducing into the joint a metallic substance. In other cases the fragment was supposedly sutured to the periosteum of the tibia. It may be possible at times to attach the fragment to the cartilage fibers or to the periosteum of the tibia, but as a rule these tissues provide no satisfactory means of attachment. Roth found that, if the fragment was held in position with forceps until the leg had been extended, the condyles then tended to hold it. Good results were obtained from the use of Roth's method, but it would appear that the fragments in his cases must have been unusually large in order for the condyles to fix them in position. In the average case the condyles do not touch the fragment, and, without any means of fixation, the pull of the ligament and the continued oozing of blood force the fragment upward.

The most satisfactory means of suturing the fragment has been suggested by Caan and Simon; the former reported no cases, but the latter carried out the procedure successfully in two cases. In principle these

Fig. 9

Case 5. Lateral roentgenogram showing an avulsion fracture of the tibial attachment of the posterior crucial ligament.

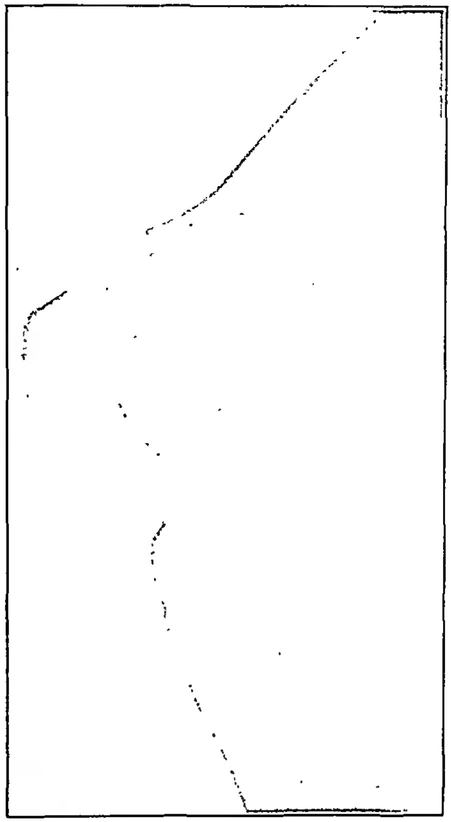

Fig. 10

Case 5. Lateral roentgenogram, taken seven years after operative reduction, showing the attachment of the posterior crucial ligament in position.

operations are similar to that of the writer, although neither Caan's nor Simon's work was known to the writer until he was reviewing the literature in preparation for this paper. The operative procedure of these writers consists of carrying sutures from the fractured surface through drill holes that lead obliquely to the anterior surface of the tibia, where the sutures are tied.

CONCLUSIONS

The operative technique described insures both reduction of the fragment and preservation of the crucial ligament in cases of avulsion fractures of the tibial attachment of the anterior or posterior crucial ligament. The method represents a decided advance in the treatment of these fractures, since by the general methods of treatment reduction is not possible and the stabilizing strength of the crucial ligament is lost.

Thus far, the technique has been carried out in four cases of fracture of the anterior crucial ligament and in two cases of avulsion of the tibial

attachment of the posterior crucial ligament. The results have been entirely satisfactory, and the patients have obtained stable, painless joints with a full range of motion.

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A TECHNIQUE FOR LESSENING HEMORRHAGE IN OPERATIONS ON THE SPINE

BY GEORGE WAGONER, M.D., HAVERFORD, PENNSYLVANIA

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Operations upon the spine usually induce hemorrhages which are difficult to control. The hemorrhage masks the field of operation and prolongs and complicates a difficult procedure. This paper presents a simplification for the subperiosteal exposure of the posterior portion of the spine. The technique was developed in 1924 by animal experimentation. Since then it has been used many times upon man by the author and by his colleagues.

ANATOMY

The profuse arterial hemorrhage, so frequently encountered in operations upon the posterior spine, results from disruption of the internal muscular branches of the dorsal divisions of the lumbar and thoracic arteries. Figure I shows how closely these arteries approximate the lateral surfaces of the spinous processes. These arteries are so deeply embedded in the spinal-muscle masses that they cannot be seen. Their avoidance is possible only through an intimate knowledge of the muscles in which they lie.

In Figure 2 is shown the cross-sectional relationship of these muscles at different levels of the spinal column.

The posterior spinal muscles may be regarded as two large muscle bulks lying in bony grooves, one on either side of the posterior midline of the vertebral column. These muscles are divided, functionally and anatomically, into three layers: a superficial, a middle, and a deep layer.

It is necessary to determine the origin and insertion of the several muscles in each of the three layers. Figure 3 shows the course and direction of the fibers of each of the muscles comprising the posterior spinal-muscle groups.

Study of this diagram shows that

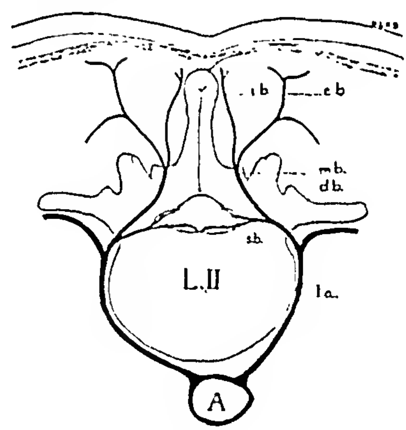


FIG. 1

Course of arteries supplying the posterior spinal muscles:
L.II = second lumbar vertebra
A = aorta
l.a. = lumbar artery
d.b. = dorsal division of lumbar artery
s.b. = spinal division of lumbar artery
m.b. = muscular branch of dorsal division
i.b. = internal muscular branch
e.b. = external muscular branch

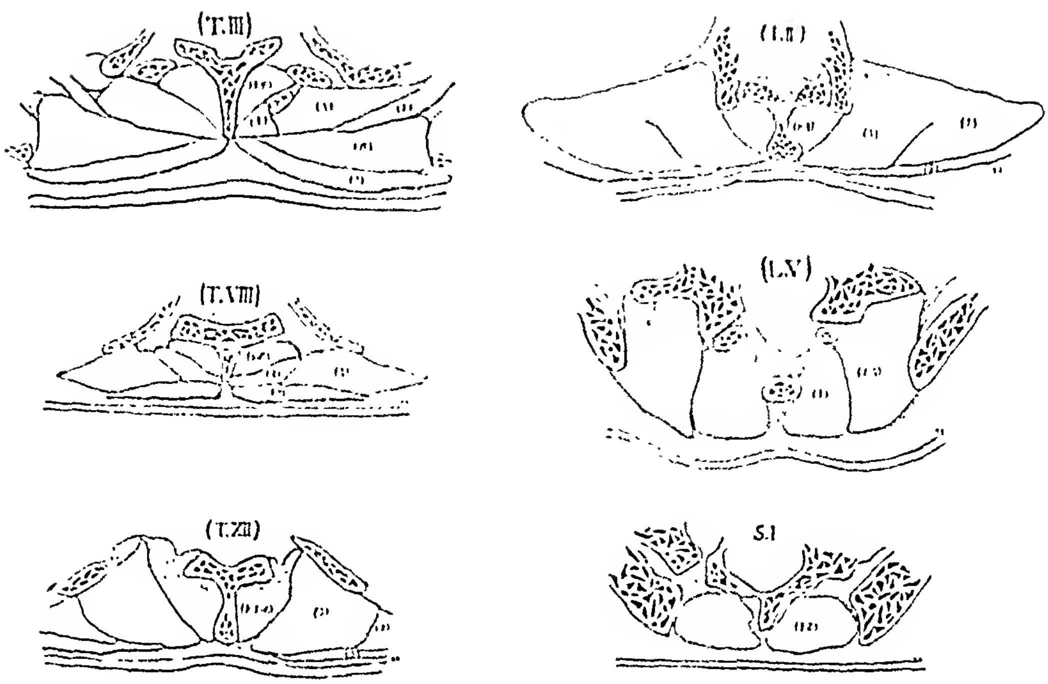


FIG. 2

Relations of the posterior spinal muscles as seen in cross-sections at various levels (adapted from "A Cross-Section Anatomy" [2]):

1 = multifidus	*6* = semispinalis dorsi
2 = iliocostalis	*7* = trapezius
3 = longissimus dorsi	*8* = rhomboideus major
4 = spinalis dorsi	*9* = longissimus cervicis
5 = latissimus dorsi	*10* = longissimus capitis

in the superficial layer the muscle fibers of the lumbar area course upward and outward, having for the most part arisen centrally. In the thoracic area the majority of the superficial muscles arise laterally and their fibers pass upward and inward.

In both the middle and the deep layers the muscles of the lumbar, thoracic, and cervical areas arise laterally and pass upward and inward.

The bulk of the posterior spinal muscles can be regarded as arising from the transverse and mammillary processes and inserting at a higher level on the lateral walls of the spinous processes and into the interspinous ligaments. It is the recognition and utilization of this arrangement which makes possible the bloodless exposure of the spinal column.

TECHNIQUE

With the patient prone, an incision is made down to the deep fascia. Bleeding points are clamped and ligated. The skin and subcutaneous tissues are freed by blunt dissection from the deep fascia for a distance of approximately three centimeters on either side of the midline.

The lowermost limit of the desired exposure is determined and the spinous process at this point is located. The superspinous ligament, extending from this spinous process to the next higher process, is palpated. The scalpel is inserted in the midline between the two spinous processes and the superspinous and interspinous ligaments joining these processes

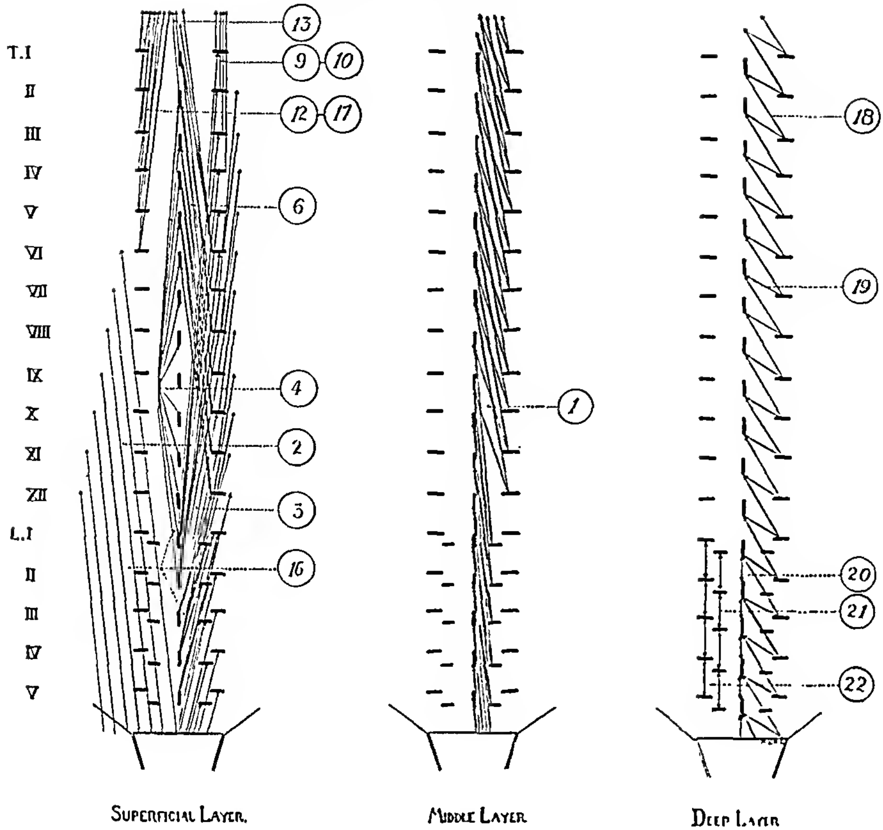


Fig. 3

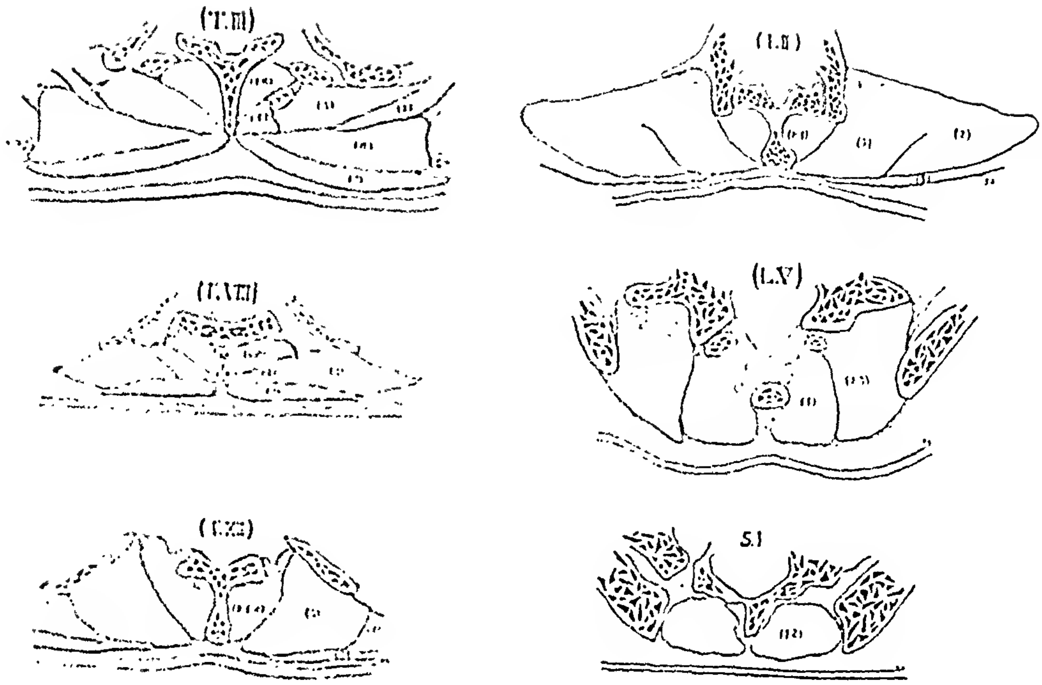
Diagram showing the lines of pull of the fibers and the relative position and extent of the muscles which lie in the posterior vertebral grooves. The origin of the fibers is indicated by the tail, the insertion by the head of the arrows. The arrows extending outside of the groove represent fibers which insert on the ribs, but originate inside of the groove. The vertical rows of dashes represent the spinous processes of the vertebrae; the outer transverse rows, the transverse processes; and the inner transverse rows in the lumbar region, the mammillary and accessory processes. (After Braus, Piersol, and Spalteholz.)

Key to muscles:

1 = multifidus	*13* = spinalis cervicis
2 = iliocostalis	*16* = erector spinae
3 = longissimus dorsi	*17* = semispinalis cervicis
4 = spinalis dorsi	*18* = rotatores longi
6 = semispinalis dorsi	*19* = rotatores breves
9 = longissimus cervicis	*20* = interspinales
10 = longissimus capitis	*21* = intertransversales mediales
12 = semispinalis capitis	*22* = intertransversales laterales

are divided longitudinally. The knife is carried vertically downward to the base of the spinous process. In the slit thus made, a straight, blunt periosteal elevator is inserted. The lower tip of this instrument is forced outward and upward until it rests against the base of the upper spinous process. (See Figure 4.)

The lower end of the elevator is held firmly against the lamina, and the exposed end of the elevator is displaced laterally. By this manipulation, the muscle fibers inserting on the upper spinous process are made taut.



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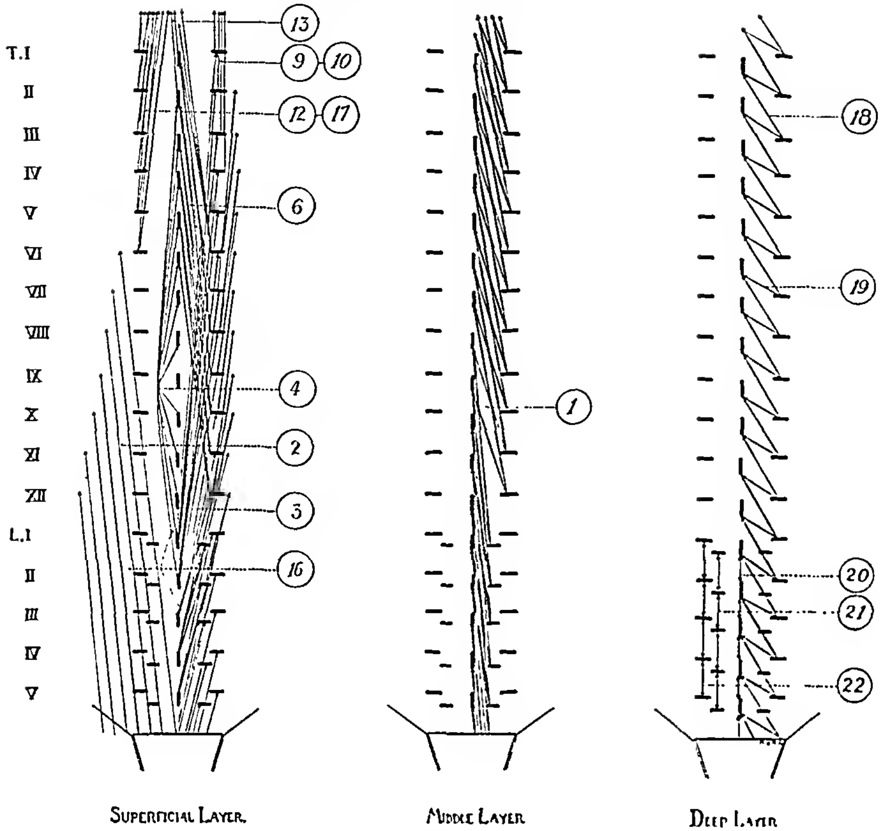

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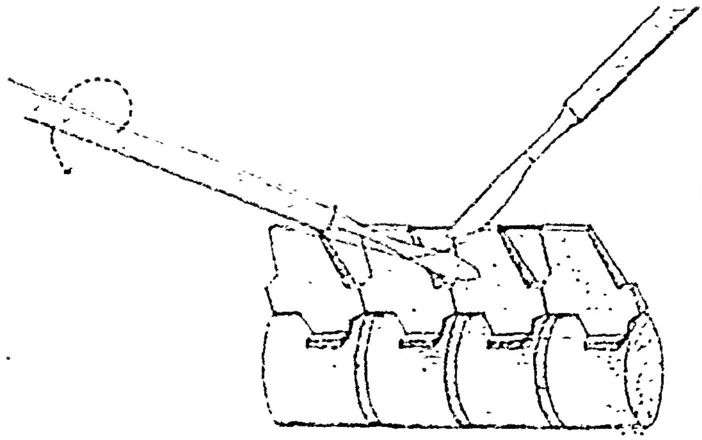

FIG. 4

Method of freeing the posterior spinal muscles from their insertions on the lateral walls of the spinous processes and to the interspinous ligaments. (The tip of the periosteal elevator should be shown held against *the base* of the spinous process.)

The taut fibers are cut from their insertion to the lateral wall of the upper spinous process. Great care is taken to free the muscle insertions subperiosteally from the spinous process and to split the interspinous ligament exactly in the midline.

When the muscle attachments are freed from one spinous process and interspinous ligament, the periosteal elevator is removed. It is then reinserted in a similar position against the base of the next higher process. This procedure is repeated until the central insertions of the posterior spinal muscles on one side of the column are freed through the desired length.

The muscles on the opposite side of the spinal column are freed in the same manner.

After the central insertions of the posterior spinal muscles on both sides have been severed, the muscles are displaced laterally by blunt dissection and retraction.

By means of this procedure, the posterior aspect of the spinal column can be exposed without encountering arterial hemorrhage. Some oozing of blood will take place from the denuded bony surfaces, but it will be insignificant in amount.

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CHANGES IN THE UPPER HUMERAL EPIPHYSIS FOLLOWING OPERATION FOR OBSTETRICAL PARALYSIS

Report of Two Cases

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Department of Orthopaedic Surgery, Cleveland Clinic

In 1924 Kleinberg described an operation for the correction of the internal-rotation deformity of obstetrical paralysis of the upper arm. In this early report, an arthrodesis of the shoulder was done also. Later, in 1932, he reported ten cases, in eight of which the internal-rotation deformity had been corrected by reattachment of the joint capsule and external rotators. In these eight cases, the simple reattachment operation was done without the accompanying shoulder arthrodesis previously reported. The operation, as described by Kleinberg, consisted in the subperiosteal detachment of the joint capsule and insertion of the internal and external rotators in the upper one and one-half inches of the humerus. After these structures had been freed, the arm was rotated externally and the lateral flap was sutured more medially and allowed to overlap the medial flap.

FIG. 1

Case 1. Before operation, June 1933.

FIG. 2
Case 1. Twenty-eight months after operation.

In the last several months, the author has observed two cases in which operation had been performed for the internal-rotation deformity incident to obstetrical paralysis of the upper arm. The patients had been operated upon by different surgeons, but the technique described in the operative notes was essentially the same. Kleinberg's method for the reattachment of the external rotators had been used. In each case, good correction had been obtained at the time of operation and a position of full external rotation was maintained. For several months after operation, the progress seemed good and there was marked improvement in the position of the extremity and an increased range of motion in the shoulder joint. Each of these patients returned, however, complaining of stiffness in the shoulder joint and loss of function. The first returned after a period of twenty-eight months and the second after a period of twenty-four months. The corrected position had been maintained. Roentgenograms (Figs. 2 and 3) showed some significant findings. In both, there were changes in the upper humeral epiphyses with deformity and irregularity in density. It occurred to the author that these changes might be explained on a basis of vascular disturbance to the epiphysis, because, in the operation for reattachment of the external rotators, the capsule and periosteum over the upper one and one-half inches of the humerus are

FIG. 3
Case 2. Two years after operation.

raised. This would account for the interruption of a major portion of the vascular supply to the epiphysis. The evolution of the change is indefinite as periodic roentgenograms were not available.

Reports of the cases of these two patients follow.

CASE 1. A male patient, aged twelve years, was seen first on April 4, 1932. The complaint was deformity and poor use of the right hand.

Examination revealed elevation of the right scapula with a marked fixed internal-rotation deformity of the shoulder joint, a flexion deformity of the elbow, and a pronation deformity of the forearm. Abduction was markedly limited and most of the abduction was scapular movement. The birth history was not remarkable, but it was recalled that at the age of three months the child had not used his right arm and that the wrist had been held in a flexed position. An abduction arm splint had been applied and worn for three months, which produced improvement. No other treatment had been administered.

A diagnosis of obstetrical paralysis of the upper arm was made.

A roentgenogram (Fig. 1) showed some deformity about the scapula and a normal upper humeral epiphysis. The shoulder was operated upon on June 22, 1933, and the capsule and external rotators were reattached after the technique of Kleinberg. The humerus was rotated externally and the new position was maintained in plaster. A fairly good functional result had been obtained by September 30, 1933.

The patient was seen again on February 1, 1935, twenty-eight months later. His complaint was inability to get his hand into his pocket. Examination revealed a good functional position. There was, however, practically no motion in the shoulder joint, and motion in internal rotation was insufficient to permit putting the hand into the pocket. A roentgenogram (Fig. 2) showed almost complete absence of the humeral

head with marked deformity of the remaining part. Subsequently, a partial arthroplasty produced considerable improvement in the *range* of *motion*.

CASE 2. A male patient, aged ten years, was first seen on June 1, 1933. Poor use of the right arm had been present since birth. History of the birth revealed a prolonged, difficult labor; the baby weighed nine and one-half pounds. Treatment had consisted in massage and manipulations.

Examination revealed that the right arm was much smaller than the left. There was an internal-rotation contracture at the shoulder, a flexion contracture at the elbow, and a pronation contracture in the forearm. The muscles acting about the hand and wrist were good. The extensors at the elbow were fair. There were no sensory changes.

A diagnosis of obstetrical paralysis of the upper arm was made. The patient was operated upon on June 8, 1933, and reattachment of the capsule and external rotators was done. Good external rotation was accomplished and the position was maintained in plaster. Function improved and a good position was obtained, but examination two years later revealed loss of function with stiffness about the shoulder and limitation in abduction. A roentgenogram (Fig. 3) showed deformity of the upper humeral epiphysis with irregularity in density. Preoperative roentgenograms were not available. Subsequent operation for muscle release improved the function slightly.

NOTE: The author is indebted to Dr. James A. Dickson, Cleveland, and to Dr. W. B. Carrell, Dallas, for permission to report these cases.

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FRACTURES AND DISLOCATIONS OF THE CERVICAL SPINE

PART II. DISLOCATIONS, COMPLICATIONS, AND OPERATIVE TREATMENT

BY SUMNER M. ROBERTS, M.D., F.A.C.S., BOSTON, MASSACHUSETTS

GENERAL CONSIDERATIONS*

From the anatomy of the atlas and the axis it is reasonable to suppose that dislocation between them can take place without fracture. The articular facets are nearly horizontal, and a sheering or twisting force meets with no bone resistance except the odontoid. This is confirmed both clinically and roentgenographically. Complete dislocation in the lower cervical spine rarely occurs without a fracture. However, an incomplete unilateral dislocation—one in which the articular facet on one side rides up and forward on its mate below without slipping off—can occur without fracture. The articular facets become more and more vertical as they progress down the cervical spine and any complete dislocation, even if unilateral, is usually accompanied by at least a minor fracture. In ten out of nineteen cases of dislocation demonstrable fractures accompanied the other injuries. In other cases they were suspected, but not proved. In one case of complete bilateral dislocation between the fifth and the sixth vertebrae (Case 23), there was no visible fracture either in the roentgenogram or at open operation. It is the author's belief that this case was decidedly an exception to the rule.

Diagnosis

Diagnosis is made on a history of injury, on the presence of pain and tenderness in the involved region, and on the characteristic position in which the head is usually held. The injury is usually a fairly severe one, but occasionally a case is seen which has resulted from comparatively minor trauma. For instance, a little girl (Case 31), while skipping rope, turned her head to call a playmate and experienced a sudden pain in her neck. Roentgenograms showed that this sudden unguarded movement had produced a complete unilateral dislocation. Certain cases of "spontaneous" dislocation of the atlas on the axis have been reported,[1,2,3] usually associated with an acute infection of the tonsils or of the mastoids. These undoubtedly occur, but, except for one case (Case 37), which may or may not have been of this type, they are outside the field of this discussion which is confined to the strictly traumatic lesions.

The position in which the head is held is quite constant, and usually gives the clue as to the type of injury that has occurred. If there is a complete dislocation on the right, the head will be turned to the left and

* In Part I of this paper fractures of the cervical spine were discussed. Some of the general considerations under that heading, particularly the section on examination and preliminary care, are also applicable to dislocations.

tilted to the right. The reason for this position is clear when we consider the anatomy of the dislocation. First, assuming that we are still dealing with a dislocation on the right, the articular process of the upper vertebra rides forward on the process of the vertebra below. This riding forward upon the right turns the head to the left. When the dislocation is complete, the upper right articular process slips forward off of the one below and drops down in front of it; this downward slip gives the head a tilt to the right. If the disloeation is incomplete, the turning of the head is present, but there is little if any tilting. In cases of bilateral complete dislocation, the head is tipped forward without rotation. Although the position of the head is characteristic of cervical dislocation, it must not be supposed that it is pathognomonic of the condition. The position of "torticollis", the head turned to one side and tipped to the other, occurs in cases of myositis, of ligamentous strain, of cervical adenitis, or in any condition that may send the muscles of one side of the neck, particularly the sternomastoid, into spasm. A diagnosis of dislocation of the cervical spine may be suspected from the position of the head, but cannot be made on that sign alone. The differential diagnosis between fracture and dislocation must depend finally upon the roentgenogram. When a positive diagnosis of dislocation has been made on physical and roentgenographic evidence, the position of the head gives valuable information as to the extent and the location of the injury.

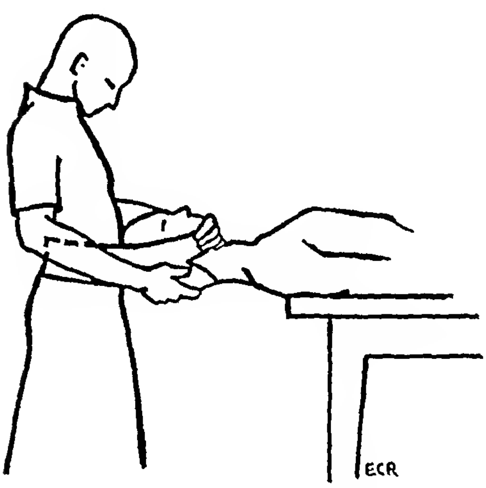

FIG. 1

Position of operator and patient during the reduction of a dislocation of the cervical spine.

Treatment

Treatment consists of immediate reduction of the dislocation, followed by plaster fixation. If the dislocation is incomplete, reduction is simple. Hyperextension and traction alone are sufficient. Three cases (Cases 21, 30, and 32) were successfully treated in this way. Usually traction for twenty-four hours with a pull of five pounds relaxes muscle spasm and restores normal relationships. When the dislocation is complete, reduction must be attempted only under anaesthesia. If the anaesthetist is acquainted with the nature of the case, the administration of an anaesthetic is not a dangerous procedure (anaesthetics were safely administered seventeen times in thirteen cases of this series). Traction in such cases is futile. No amount of direct pull will unlock the articular facets. Manipulation is necessary. The method used in this series of cases is that described by Walton in 1904. This has successfully stood the test of thirty years. Based as it is upon correct mechanical principles and

thorough understanding of anatomy, it is one of the finest examples of clear, logical theory borne out by practical experience.

The anaesthetic should be administered only by a skilled anaesthetist, since all struggling must be prevented. For this reason, induction with non-irritating gases is desirable. Avertin is ideal for these cases, but it has to be supplemented with ether in order to get sufficient relaxation. The anaesthetist should be instructed that, in case there is any struggling, forward flexion of the head and neck must be prevented at all costs.

When complete relaxation has been obtained, the patient is placed flat on his back with the top of his head flush with the end of the table. The operator stands at the head of the table, so that the patient's head is against his abdomen. A strip of non-elastic cloth, six inches wide, is then split longitudinally in its center for about eight inches. The patient's head is passed through this slit, so that one band of cloth comes under his occiput and one under his chin. The ends of the cloth are then tied tightly behind the operator's back. In this way a moderate amount of traction can be applied to the neck and the operator's hands still remain free. (See Figure 1.)

FIG. 2-A FIG. 2-B

Case 37. Position of head eleven months after dislocation of the atlas on the axis. No treatment was given during this time.

FIG. 2-C

Case 37. One year after manipulation. The clinical improvement was marked, although the anatomical change was very slight.

The author believes that the dangers of manipulation have been greatly exaggerated. Not only have there been no fatalities in this series in which there were ten successful manipulations, but there have been no nerve or cord complications. Fatalities occur, but so few of them have been reported that it is difficult to explain their cause accurately or to judge their frequency. In the writer's opinion, however, two main factors

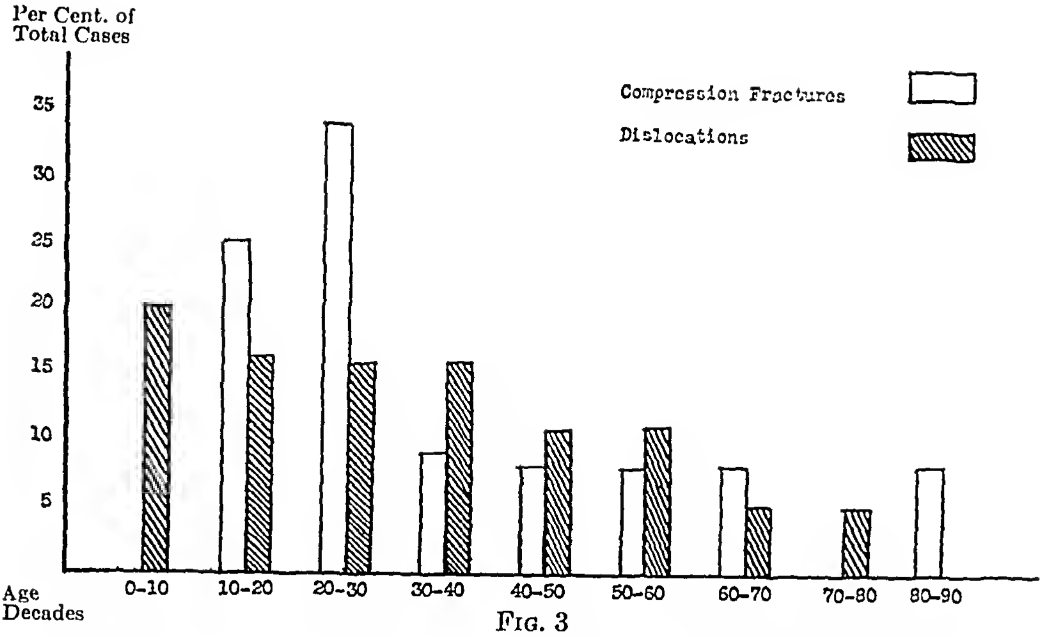

FIG. 3

Age incidence of cervical injuries. In the first decade of life, injury to the cervical spine results in dislocation rather than in fracture. After this first decade, the age incidence of the two injuries is much the same.

are responsible for these deaths. First, the operator has been unskilful and has relied upon strength rather than upon finesse. Second, fracture has accompanied the dislocation. The small fractures of the facets and the pedicles previously mentioned do not seem to be serious, but, if there is a compression fracture of the body associated with the dislocation, the operator should hesitate long before attempting manipulation. In such a case, it is better to treat the compression fracture and to allow the dislocation to go untreated. Successful healing of the fracture with a bony bridge between the injured vertebra and its neighbors will stabilize the spine so that increase in the dislocation will not occur.

The sooner reduction is attempted, the better is the chance of success. This has become almost axiomatic for other parts of the body, and the cervical spine is no exception. How long can one wait and still have a chance of being successful? In one case (Case 26) manipulation was done four months after injury with correction of approximately 50 per cent.—*i.e.*, no deformity now exists, but the patient still cannot rotate her head to the side opposite to the original deformity. One case, in which treatment was attempted ten months after injury, resulted in very little bone change, but there was about 80 per cent. improvement in deformity. Not enough old cases have been treated to answer our question, but the writer believes that, in the upper cervical spine at least, an attempt at correction should be made even after ten months if there is a permanent deformity of the head and neck. (See Figures 2-A, 2-B, and 2-C.)

After reduction has been obtained, a plaster jacket and head piece are applied in the manner already described in Part I. A complete dislocation should be held by plaster for two months, by a leather collar for two months, and, finally, by a Thomas collar for two more months. In the

case of an incomplete dislocation, plaster can be dispensed with entirely and a molded leather collar can be worn for two months, followed by a Thomas collar for one month.

After the first eight weeks, active exercises must be begun or else the muscles of the neck will become so weak that they will be unable to support the neck when freedom is finally allowed. The exercises should be of the simple postural type and should be designed to teach the patient to hold his head up and chin in in the correct mechanical position. When the leather collar is first removed for exercises, the patient should be lying down on his back without a pillow. All exercises should be done in the recumbent position for the first two or three weeks before the patient is graduated to a sitting or standing group of exercises. It is extremely

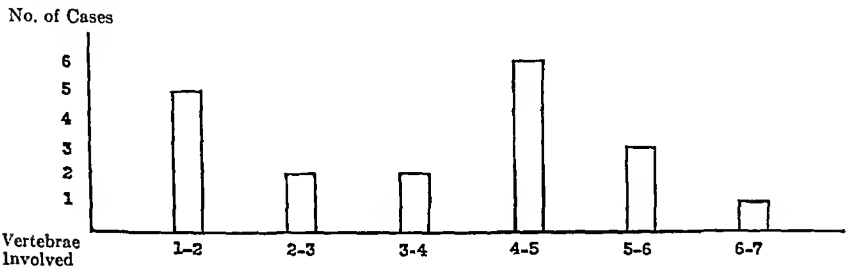

Fig. 4

Location of injury dislocations. The greatest number of dislocations occur between the first and second cervical vertebrae, where the articular facets are most horizontal and where there is no spinous-ligament attachment; also between the fourth and fifth cervical vertebrae, or at the apex of the curve when the neck is flexed.

important that the transition from complete fixation to complete freedom should be gradual and accompanied by active muscle training.

In this series, dislocations were more numerous than fractures and, in addition, they showed a more varied age incidence. (See Figure 3.) Dislocation occurred most frequently between the fourth and fifth vertebrae and next between the first and second vertebrae (Fig. 4). The younger the patient, the higher the dislocation seemed to occur. The youngest patient was seven years old, and there were three patients who were nine years of age. Two of these four patients had dislocations between the first and the second vertebrae and two between the second and third vertebrae. On the other hand, the six patients having dislocations between the fourth and fifth vertebrae ranged in age between twenty-one and seventy-four years. The average age of the patients with dislocations in the upper half of the cervical spine was twenty years as against forty-two years for those with dislocations in the lower half.

COMPLICATIONS

Early Complications

These are the complications that occur at or immediately after the time of injury and before any treatment has begun. Any severe injury

to the cervical spine, whether it be a fracture or a dislocation, may be accompanied by neurological symptoms. The most common symptoms are pain and weakness in the shoulders and in the upper extremities. These are often transient and clear up in from a few minutes to a few weeks. They are probably due to a nerve-root pressure, resulting from the general oedema that accompanies all trauma to the soft tissues. If the nerve roots are forcibly stretched, or if they are impinged upon by bone fragments, the symptoms are more severe, and there may be permanent impairment of function of the upper extremities. These complications are the result of damage received at the time of injury. They cannot be prevented, but they may be augmented by improper handling of the case.

Two of the twelve cases of fracture of the vertebral body (Cases 11 and 15) showed permanent nerve-root symptoms, and one case (Case 12) showed transient symptoms. In one case of dislocation (Case 19) there was transient nerve involvement, and two patients (Cases 20 and 21) are at present improving, although whether or not they will finally be symptomless it is not now possible to state.

More serious are the symptoms due to cord compression. This structure may be so seriously damaged that it will never recover wholly or in part. Contrary to general belief, fatal cord injury seldom accompanies a dislocation, even if the dislocation is complete. In only one of the cases with a fatal outcome in this series was there a dislocation (Case 23). The roentgenographic picture of a dislocation is much more alarming as a rule than that of a fracture. Nevertheless, the latter is much more serious. Because only one dislocation unaccompanied by a fracture was fatal, and because most of the deaths occurred following fracture without dislocation, it is the author's belief that when the two injuries (fracture and dislocation) occur together with a fatal outcome it is the fracture element that is responsible for death. Occasionally hemorrhage into the cord (hematomyelia) will give localized symptoms which are permanent (Case 10). The duration of cord symptoms cannot be determined at once, except in very serious injuries, and even with complete cord block or severance the duration of life cannot be predicted. The treatment of these cases of early cord injuries will be discussed later when the operative treatment is considered. When cord symptoms are present, however, the sooner the fracture or dislocation is reduced, the better are the chances of recovery.

Nine, or 75 per cent., of the fracture cases showed symptoms of cord compression. In five of these cases (Cases 7, 9, 13, 17, and 18) the cord damage was permanent. Three patients (Cases 11, 12, and 14) had cord symptoms which completely cleared up, and one patient (Case 10) improved but never got entirely well. The cases of dislocation were less serious as far as cord damage was concerned; only two patients (Cases 23 and 24), or 10.5 per cent., had permanent injury. Two cases of dislocation (Cases 26 and 28) showed evidence of transient cord involvement. The difference between fractures and dislocations is again seen when we com-

pare the number of nerve complications, both root and cord, accompanying each type of injury. In each of the twelve cases of compression fracture there was some sort of nerve-tissue involvement. Out of nineteen cases of dislocation there were nerve symptoms in only seven.

Late Complications

Distinct from the immediate symptoms of nerve-tissue injury are those that sometimes appear after the initial effects of injury have disappeared or even after recovery is apparently complete. These may be either of the nerve-root or of the cord type. They may not appear for some time after injury. Their occurrence is due to the gradual increase of scar tissue or of bone callus. In order to guard against them, all unnecessary irritation of tissues must be prevented. This is the main reason for the prolonged fixation used in these types of injury. If fixation is removed too early, there is a strain upon the injured parts that have not fully healed, and, in an attempt to prevent further strain, nature overdoes in her repair work. The untreated or unrecognized cases offer the best examples of late complications.

One patient in this series (Case 20) had no nerve symptoms until four

Fig. 5

Complete dislocation of the atlas on the axis, showing how extreme a dislocation may be without resulting in death or even in injury to the cord. The odontoid is fractured and carried forward, allowing the cord to curve around and to enter the foramen magnum uninjured. This illustration also shows the type of injury in which, if untreated, scar tissue may form and cause late cord symptoms. In this instance, they appeared after three months.

days after injury when he began to notice numbness and weakness of his left arm. This man had had no treatment following injury and his delayed symptoms were undoubtedly due to the weight of his unsupported head which added insult to an already injured area. Case 33 was the best example of delayed symptoms. Four months after an untreated dislocation, the patient, who had returned to work, began to have cord symptoms. These started as tinglings in his fingers and progressed so that in two weeks he was unable to walk. A similar case is that shown in Figure 5. This man had only local symptoms at the time of injury, but three months later he began to have weakness of his arms followed by spasticity of his legs.*

Redislocations occasionally occur. Sometimes the fault lies with the patient who removes the plaster without the surgeon's consent or knowledge; sometimes it is the surgeon's fault when he removes fixative apparatus too early. In either case the reason is the same,—the cervical spine has not been protected long enough. Such a complication should not occur if fixation is adequate. One patient (Case 21) was taken to the x-ray room on the seventh day after dislocation because roentgenograms taken with the portable machine were not satisfactory, and additional injury at a lower level was suspected. In spite of precautions, the dislocation partially recurred. Fortunately, there were no untoward events and reduction was again obtained by head traction, but this shows how easily redislocations may occur during the early stages of convalescence. In another case (Case 27) reduction was satisfactorily obtained by manipulation and three weeks later there was a partial recurrence while a plaster jacket and head piece were being applied. A third patient (Case 20) had a recurrence of deformity after eight weeks of head traction. This man, however, did not have a dislocation, but a fracture of the lamina with a slipping forward of the upper vertebra, simulating a dislocation.

OPERATIVE TREATMENT

In this series of cases operation has been performed for three reasons: (1) to attempt a reduction of the injury when closed methods have failed (Cases 20 and 23); (2) to stabilize a spine in order to prevent a feared recurrence of the deformity (Cases 24 and 27); and (3) to relieve the spinal cord from pressure (Cases 18 and 33).

1. It is very rarely necessary to perform an open operation. If an accurate diagnosis of the type of injury is made, the closed methods of treatment described will suffice. The two operations performed in this series were because of this "if". In both cases, an erroneous diagnosis was made. In one case (Case 23) the dislocation was bilateral, but was diagnosed as unilateral. It is possible that, even if a correct diagnosis had been made at first, operation still would have been necessary because

* This case is not included in any of the statistics since it was not treated here and the roentgenogram is used through the courtesy of Dr. Harlan Wilson, of Columbus, Ohio, who first saw the case when cord symptoms appeared and who incidentally relieved them.

for some reason, not clear, the order of reduction had to be right side and then left side, and, if a closed reduction had been attempted in the reverse order, it would have failed. What actually happened was that, because dislocation was believed to have occurred only on the left, reduction was attempted only on that side, with resultant failure. The other case (Case 20) was the one in which a disagnosis of bilateral dislocation was made when actually there was a dislocation on one side only and a fractured lamina on the other. At operation it was found impossible to hold the fracture in a reduced position. With greater accuracy of diagnosis, therefore, this type of operation should be unnecessary.

2. Two operations were performed because of fear of recurring deformity. Probably both of these were unnecessary. They were done on early cases in this series and before definite principles of treatment had been formulated. The fact that in no case has there been a recurrence of deformity following adequate fixation shows that stabilization operations are very rarely, if ever, needed. The exception to this rule is the case of congenital absence of the odontoid (Case 30) which surely needed stabilization. Another type of case that probably would require operative fixation is an ununited odontoid which has permitted an atlanto-axial dislocation. In stabilizing such cases, it has been the author's practice to lash the spinous processes (or the posterior arch of the atlas) together with fascia lata.

Sometimes the trauma of dislocation injures the intervertebral disc so that this structure gradually collapses, allowing the upper vertebra to settle down on top of the lower. Roentgenographically, this may simulate a partial redislocation (Case 34), but it should not be considered as such, since it is the result of the original trauma and is in no way the fault of treatment.

3. If the first two types of operations are seldom used, the third type is unfortunately more common. The indications for this operation (laminectomy) can best be described by considering a typical case of cord compression. A patient enters the hospital with a story of injury to his neck and the roentgenogram shows a compression fracture. There is complete paralysis below the level of injury. The immediate question is: Has the cord been compressed momentarily at the time of injury, and is this pressure now released, or is the cord still being constricted? In the former case laminectomy will do little good, but in the latter it may help. If lumbar puncture does not show a block, then the cord is probably not being seriously impinged upon. If a complete block is present, the cord is still being pressed upon by the bony deformity, or else it is so oedematous that it fills the neural canal. In either case, pressure must be relieved. The most logical way to relieve pressure is to reduce the deformity. This should be done and should be followed by another lumbar puncture. If block no longer exists, operation is not needed (Case 13). If block is still present, laminectomy must be done. The question may arise: Why not do an immediate laminectomy and reduce the deformity at the time of

operation? The answer is that laminectomy in this region, in the face of complete cord block, is a serious operation with a high mortality (100 per cent. in this series of cases, and without any evidence of relief of cord symptoms before death). Of what use, then, is operation? The answer is that it is conceivable that the cord can be temporarily injured and that, if the cause of injury be removed promptly enough, there will still be some power of regeneration left in the nerve tissues. The fact that this has never occurred in this series of cases does not rule it out.

Cord symptoms that arise as a late complication are more likely to benefit from laminectomy than the early symptoms. These come on gradually due to excess scar and callus formation (Fig. 5). The cord does not undergo a sudden, severe injury, but is gradually encroached upon. If the impinging forces can be removed reasonably early, the chances for recovery are good. Late cord symptoms do not come on as a rule for several months, at which time the patient has recovered from the shock of the initial injury and is in good condition for operation. In the only case of this sort operated upon in this series (Case 33), the results were most striking. The patient entered the hospital unable to stand; after recovery from laminectomy, he walked out and returned to his former occupation.

MORTALITY

There was only one *death attributable to dislocation alone* (Case 23). Another was due to post-manipulation pneumonia (Case 29). As has been mentioned before, most deaths were in cases of fracture alone (Cases 9, 17 and 18) or in cases of combined fracture and dislocation (Cases 7 and 24), in which the latter element was of minor importance. The spinal canal, therefore, is large enough and the cord is adaptable enough to permit a complete dislocation without cord pressure (Case 33 and Fig. 5). In cases of dislocation, the cord, although curving out of its normal course, still runs in a canal of normal size and smoothness. In cases of fracture, however, the compressing force of the injury constricts the spinal canal and this the cord cannot stand. If not actually severed, it becomes oedematous and the oedema in a narrowed canal causes further pressure. In all of the cases in this series death has followed such an injury. The patients have died within a week (Cases 7, 17, 18, and 23) or they have remained completely paralyzed, dying later from respiratory or kidney infections (Case 24).

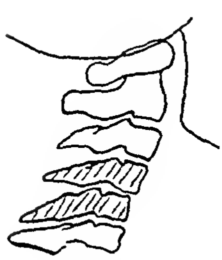

FIG. 6-A

Case 19. Dislocation of the fourth cervical vertebra on the fifth. Tracing from roentgenogram taken July 15, 1932.

FIG. 6-B

Case 19. July 22, 1932. After manipulation.

The mortality for the whole series was seven out of thirty-seven cases, or 19 per cent. Of the patients with

compression fractures, 42 per cent. died; two of these patients had slight dislocations also, which probably played no part in the picture. Death occurred in 12 per cent. of the cases of dislocation. One of the dislocation deaths was due to post-manipulative pneumonia, which leaves a mortality of 6 per cent. actually due to the injury itself.

CASE REPORTS *

CASE 19. M. B., female, aged fifty.

July 1932: As the result of an automobile accident, the patient sustained a dislocation of the fourth cervical vertebra on the fifth. Weakness and sensory changes in the right arm resulted. Treatment consisted of manipulation and immobilization in plaster for one month, followed by a leather collar for four months.

December 1934: Clinical and roentgenographic examinations showed the arm to be normal, with good motion and no symptoms.

CASE 20. M. D. C., male, twenty-eight years of age.

December 1934: Due to an automobile accident, the patient suffered dislocation of the fourth cervical vertebra on the fifth and a fracture of the lamina of the fifth vertebra. Four days later, weakness and numbness of the left arm developed. A diagnosis of bilateral dislocation was made. Treatment consisted of manipulation, and reduction was obtained on the right side, but not on the left. Traction was applied for twelve days, without change. At operation the dislocation on the right side was found to have been reduced. There was no dislocation on the left side, but a fracture of the lamina of the fifth vertebra was revealed, which could not be reduced. Traction was applied for ten weeks, followed by a leather collar.

March 1935: The patient was still wearing the collar. The arm was much improved.

This case shows the necessity for accurate roentgenographic diagnosis before treatment.

CASE 21. H. E., male, thirty-one years old.

August 1934: As the result of an automobile accident, the patient sustained a dislocation of the fifth cervical vertebra on the sixth with fracture. The right arm was paralyzed for five minutes and there was numbness of the legs for ten minutes. Neurological examination revealed a diminution of the reflexes in

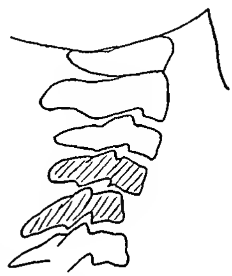

FIG. 7-A

Case 20. December 1, 1934. Dislocation of the fourth cervical vertebra on the fifth and fracture of the lamina of the fifth cervical vertebra.

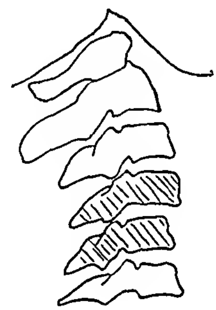

FIG. 7-B

Case 20. December 11, 1934. Partial reduction only by manipulation.

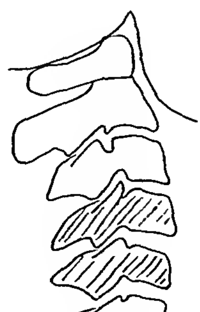

FIG. 7-C

Case 20. December 21, 1934. After open reduction.

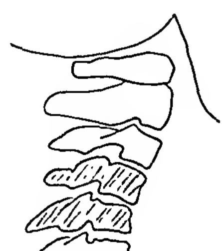

FIG. 7-D

Case 20. February 25, 1935. Partial recurrence three months after injury.

* The first eighteen cases were reported in Part I of this paper, which dealt with fractures.[4]

FIG. 8-A

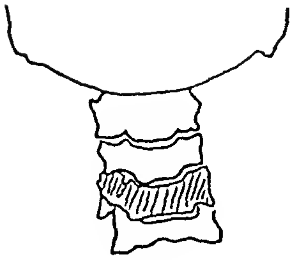

FIG. 8-B

Case 21. August 11, 1934. Dislocation of the fifth cervical vertebra on the sixth, with fracture.

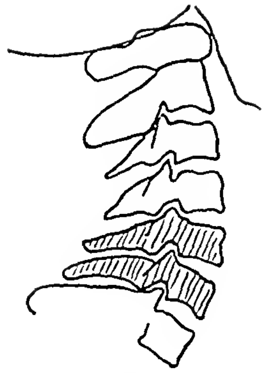

FIG. 8-C

Case 21. August 13, 1934. Initial reduction.

FIG. 8-D

Case 21. August 18, 1934. Partial recurrence.

the arms and impairment of sensation. Treatment consisted of the application of traction. Roentgenographic examination showed reduction. A week later the patient was taken to the x-ray room and the dislocation recurred. Traction was again applied and reduction was obtained. Traction was maintained for a period of six weeks, followed by a leather collar for four months.

February 1935: There were no neck symptoms, but a slight weakness of the right arm was present, which was improving.

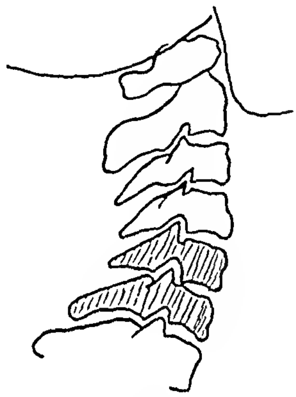

FIG. 8-E

Case 21. December 18, 1934. Final reduction four months after injury.

Fixation should not be removed too early or dislocation will recur. It recurred in this case in spite of the fact that the doctor in charge watched the patient all the time when he was taken to the x-ray room.

CASE 22. D. T., female, nine years of age.

February 1931: While coasting, the patient sustained a dislocation of the first cervical vertebra on the second. Traction was applied for three days, without change. Manipulation was then done, followed by immobilization in plaster for two months. A leather collar was then worn for two months, after which a Thomas collar was worn for an additional two months.

October 1932: Motions were normal and there were no symptoms. Roentgenographic examination was negative.

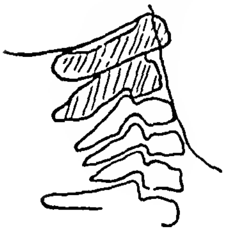

FIG. 9-A

Case 22. February 11, 1931. Dislocation of the first cervical vertebra on the second.

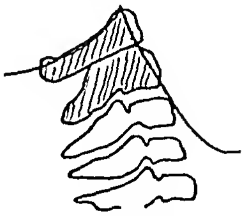

FIG. 9-B

Case 22. February 17, 1931. After manipulation.

Dislocation without fracture is common in this region, but rare lower down in the cervical spine.

CASE 23. L. F., male, aged twenty.

November 1934: While playing football, the patient suffered a dislocation of the fifth

Fig. 10-A
Case 23. November 3, 1934. Dislocation of tbe fifth cervical vertebra on the sixth.

Fig. 10-B
Case 23. November 3, 1934. After manipulation had failed.

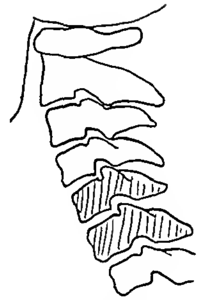

Fig. 10-C
Case 23. November 7, 1934. After open reduction.

cervical vertebra on the sixth. Complete paralysis followed. Lumbar puncture was negative. A diagnosis of dislocation on the right side was made. Treatment consisted of manipulation, which failed. Operation revealed bilateral dislocation. It was necessary to reduce the dislocation on the left side before that of the right side. The patient died six days later.

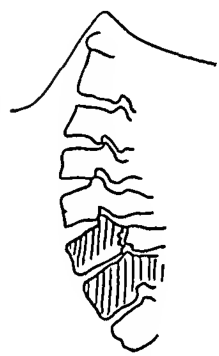

Fig. 11-B
Case 24. December 25, 1927. After manipulation and stabilization operation.

This was the only fatal case of dislocation without fracture.

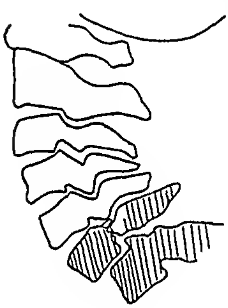

Fig. 11-A
Case 24. October 21, 1927. Dislocation of tbe sixth cervical vertebra on the seventh, with fracture.

Case 24. C. H., male, fifty-two years of age.

October 1927: The patient fell thirty-five feet, sustaining a dislocation of the sixth cervical vertebra on the seventh with fracture. Complete paralysis developed on the left side and partial paralysis on the right. The patient was kept in bed for two and one-half weeks without treatment. Manipulation at the end of this time brought about some improvement. At operation, the spinous processes were lashed with fascia.

April 1928: The patient died. There was never any change in cord symptoms.

It is the author's belief that the cord symptoms were due to the fracture and not to the dislocation. An operation was performed because of fear of recurrence of the dislocation. Adequate fixation alone would have sufficed.

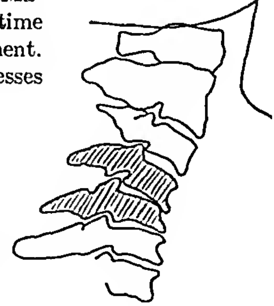

Fig. 12
Case 25. December 5, 1931. Dislocation of the fourth cervical vertebra on the fifth, eight months after injury.

Case 25. J. H., male, aged seventy-four.

April 1931: While showing his grandchildren how to stand on their heads, the patient suffered a dislocation of the

fourth cervical vertebra on the fifth. There was transient pain down both shoulders. The patient was kept in bed for one month, but was given no other treatment.

December 1931: The patient entered the hospital because of a stiff neck. Neurological examination was negative. Treatment consisted of exercises and physiotherapy.

June 1932: The patient's neck was limber. Occasional pain was relieved when the patient lay down.

One should not stand on one's head at seventy-four!

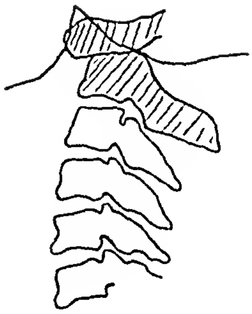

Fig. 13-A

Case 26. November 8, 1930. Dislocation of the first cervical vertebra on the second, four months after injury.

Fig. 13-B

Case 26. March 11, 1931. Three months after manipulation.

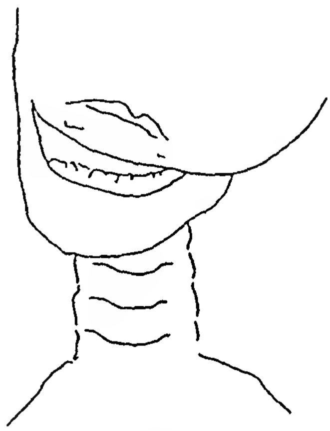

Fig. 13-C

Case 26. November 8, 1930. Position of head four months after injury.

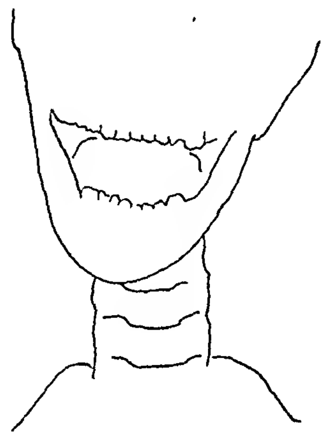

Fig. 13-D

Case 26. March 11, 1931. Position of head three months after manipulation.

Case 26. D. J., female, twenty-nine years old.

July 1930: The patient dove in shallow water, sustaining a dislocation of the first cervical vertebra on the second. Transient paralysis of all extremities followed. The patient was kept in bed for five weeks.

November 1930: On admission to the hospital, the patient's head was turned toward the left and tilted toward the right. This could not be corrected. After manipulation, there was clinical improvement. The patient was immobilized in plaster for two months. A leather collar was then worn for one month, followed by a Thomas collar for one month.

April 1931: The chin was within half an inch of the mid-line and there was no visible deformity.

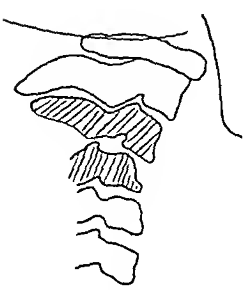

Fig. 14-A

Case 27. October 20, 1926. Dislocation of the third cervical vertebra on the fourth.

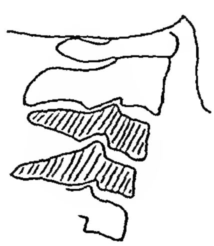

Fig. 14-B

Case 27. November 5, 1926. After manipulation.

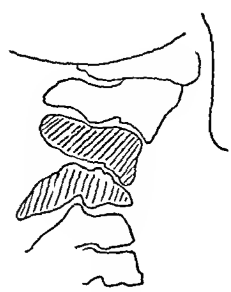

Fig. 14-C

Case 27. January 20, 1928. Fifteen months after injury. Partial recurrence, due to loss of bony substance of the fourth vertebra.

Some improvement is possible even after four months.

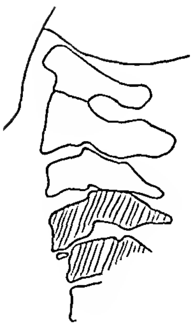

FIG. 15-A

Case 28. July 30, 1932. Dislocation of the fourth cervical vertebra on the fifth.

CASE 27. J. J., male, fifteen years of age.

October 1926: The patient was caught in some machinery and suffered a dislocation of the third cervical vertebra on the fourth. Manipulation resulted in good correction. Traction was applied for three weeks, followed by immobilization in plaster. There was partial recurrence. At operation, the spinous processes were lashed with fascia. The position of the vertebrae remained unchanged. Immobilization in plaster for three months followed.

January 1928: There were no symptoms and roentgenographic examination revealed no change.

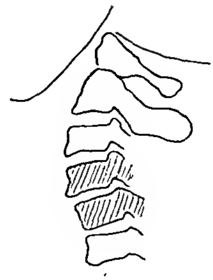

FIG. 15-B

Case 28. August 3, 1932. After manipulation.

In this case, adequate initial fixation would have made operation unnecessary. The type of operation is good.

CASE 28. E. L., male, aged sixty-five.

July 1932: The patient was tossed by a bull and sustained a dislocation of the fourth cervical vertebra on the fifth. There was transient paralysis of the arms.

August 1932: On admission to the hospital, no evidence of cord damage could be observed. Treatment consisted of manipulation, followed by immobilization in plaster for two months. The plaster was removed by the patient at the end of this period.

October 1933: The patient never returned after discharge. A letter received at this time stated: "Neck O. K. Cannot come in. Am working in woods."

In this case the fixation was inadequate. Roentgenographic examination now would probably show some slight slumping forward of the upper vertebra.

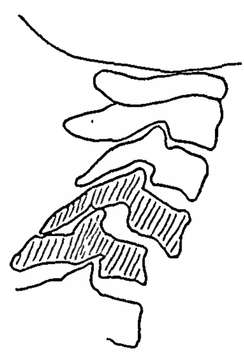

FIG. 16-A

Case 29. December 14, 1932. Dislocation of the fourth cervical vertebra on the fifth.

CASE 29. J. M., male, forty-five years old.

December 14, 1932: While drunk, the patient was thrown downstairs by his landlady and lay out in the snow all night. Roentgenographic examination disclosed a dislocation of the fourth cervical vertebra on the fifth. Neurological examination was negative. Traction was applied for two days, without change. Following successful manipulation, the patient was immobilized in plaster, which was removed after three days because pneumonia had developed.

December 22, 1932: The patient died.

In this case of severe dislocation without cord involvement,

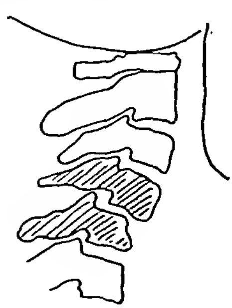

FIG. 16-B

Case 29. December 16, 1932. Failure of traction.

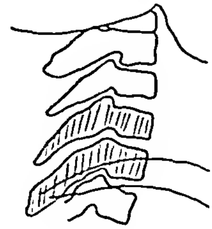

FIG. 16-C

Case 29. December 18, 1932. After manipulation.

death was due to anaesthesia on top of exposure to cold and wet. Manipulation should have been delayed.

CASE 30. O. N., male, twenty years of age.

September 1931: While "bridging" in a gymnasium, the patient sustained a dislocation of the first cervical vertebra on the second, causing sudden pain in the neck. The clinical diagnosis was: "Forward dislocation on left". The roentgenographic diagnosis was: "Backward dislocation on right; congenital absence of odontoid". Treatment consisted of traction with complete reduction, followed by a leather collar for three months.

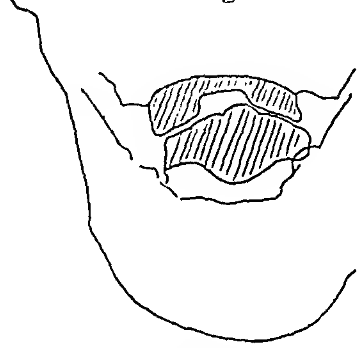

FIG. 17-A

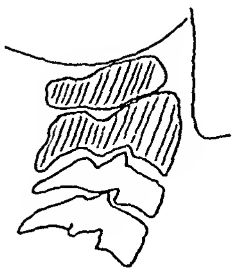

FIG. 17-B

Case 30. September 3, 1931. Dislocation of the first cervical vertebra on the second.

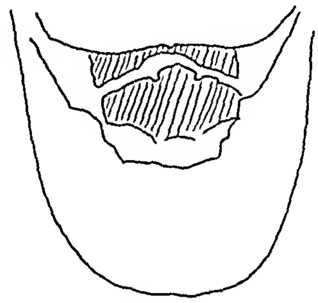

FIG. 17-C

Case 30. September 20, 1931. After traction.

October 1932: There were no symptoms and motion was normal. Operation was refused.

This case shows what might happen to an ununited odontoid. The patient should have had a stabilization operation.

CASE 31. T. P., female, nine years old.

November 1932: While skipping rope, the patient turned her head suddenly and suffered a dislocation of the second cervical vertebra on the third. Manipulation was done, followed by immobilization in plaster for two months and a Thomas collar for an additional two months.

November 1933: There were no symptoms and motion was normal.

Palpation of the posterior nasopharynx through the mouth showed an abnormal relationship which otherwise could not be felt.

CASE 32. G. P., female, nine years of age.

January 1932: The patient fell off a sofa and sustained a dislocation of the second cervical vertebra on the third. Treatment consisted of head traction, followed by a brace for six weeks. The patient could not afford a leather collar. At the end of this period, a Thomas collar was worn for two weeks.

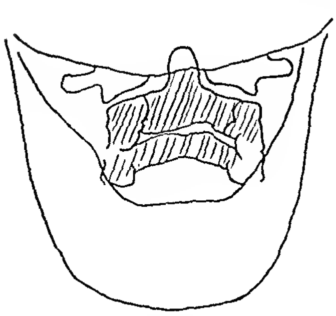

FIG. 18-A

Case 31. November 4, 1932. Dislocation of the second cervical vertebra on the third.

January 1933: There were no symptoms and motion was normal.

This was a border-line case. If the question: Is it dislocated? arises, the only way to find out is to treat the case and see if there is

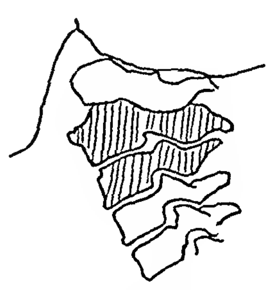

FIG. 18-B

Case 31. November 9, 1932. Note rotation of axis without forward displacement.

improvement. If traction makes no change, then there is probably no dislocation.

Case 33. W. S., male, aged fifty-three.

November 1931: The patient fell down a flight of stairs and sustained a dislocation of the first cervical vertebra on the second, and fracture of the odontoid. He remained at home for three weeks and then returned to work.

March 4, 1932: The patient experienced a prickling sensation in his fingers.

March 12, 1932: A week later he was unable to button his clothes.

March 14, 1932: He complained of numbness of the feet.

March 16, 1932: The patient began to stagger and stopped working.

March 18, 1932: He was unable to walk and was admitted to the hospital. Examination disclosed weakness and atrophy of the hands and arms. All reflexes were hyperactive. Treatment consisted of laminectomy. At operation, it was found that the cord made an S turn at the site of injury and was bound down by adhesions.

July 1932: The patient's arms and legs were nearly normal. He walked well and could button his clothes.

This was a severe case without cord symptoms for three months. The symptoms were due to the formation of scar tissue and not to bone impingement. This case was ideal for operation and is typical of late cord complication.

Case 34. A. V., male, forty years of age.

April 1929: The patient was thrown off a wagon and sustained a dislocation of the fifth cervical vertebra on the sixth. He was kept in a local hospital for ten days.

April 1930: The patient entered the hospital complaining of pain in the neck. Treatment consisted of a Thomas collar for sixteen weeks and physiotherapy.

January 1931: The patient still complained of pain. Motion was normal.

June 1931: Pain was still present, but the patient was back at work.

January 1932: Because of the persisting pain, the patient had stopped work. Neurological and medical consultations resulted in a diagnosis of compensation neurosis.

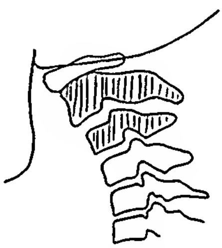

Fig. 19-A

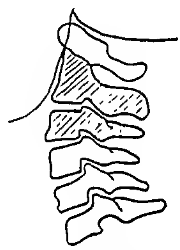

Fig. 19-B

Fig. 19-A: Case 32. January 14, 1932. Dislocation of the second cervical vertebra on the third.

Fig. 19-B: Case 32. January 18, 1933.

Early adequate treatment might have saved all this trouble.

Case 35. E. W., male, aged thirty-three.

May 1930: The patient fell off a truck and suffered a dislocation of the third cervical vertebra on the fourth, and fracture of the odontoid. For three days, he experienced difficulty in swallowing.

June 1930: The patient entered the hospital. Treatment consisted of a leather collar for three months, followed by a Thomas collar for one month. Manipulation was not done because of the fracture of the odontoid and a fracture of the lateral mass of the third cervical vertebra.

January 1931: The patient was back at work. Motion was normal, but he stated that there was some discomfort

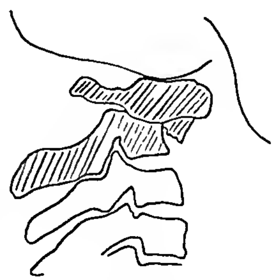

Fig. 20

Case 33. March 18, 1932. Dislocation of the first cervical vertebra on the second, and fracture of the odontoid. Roentgenogram four months after injury.

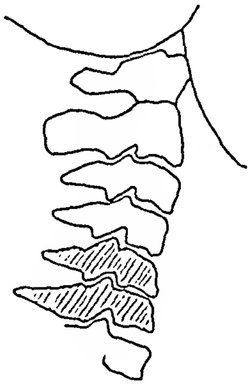

Fig. 21

Case 34. November 27, 1931. Dislocation of the fifth cervical vertebra on the sixth. Roentgenogram two years and seven months after injury, showing loss of intervertebral disc.

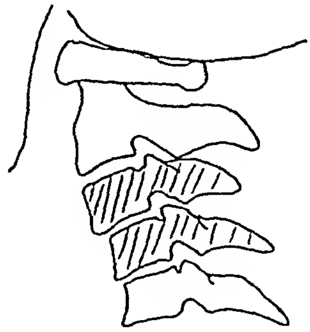

Fig. 22-A

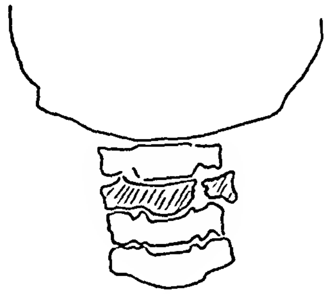

Fig. 22-B

Case 35. June 12, 1930. Dislocation of the third cervical vertebra on the fourth, and fracture of the odontoid, one month after injury.

if he kept his head bent down very long. There had been no recurrence of the dislocation, and the odontoid had united.

Adequate fixation resulted in union of the odontoid. Manipulation in the presence of fractures should be done cautiously, if at all.

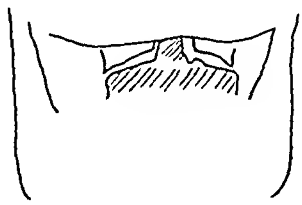

Fig. 22-C

Case 35. January 9, 1931. Seven months after injury.

Case 36. C. W., male, twenty-one years old.

April 1930: The patient fell off a roof and sustained a dislocation of the fourth cervical vertebra on the fifth. Treatment consisted of manipulation, immobilization in plaster for three months, and a leather collar for two months. During the period of immobilization, weakness and atrophy of the left shoulder were discovered. The question then arose: Was this present before?

September 1930: Motion was normal. Atrophy and weakness had disappeared.

November 1930: There were no symptoms.

Neurological examination should always be done at once, so that it may be referred to later if nerve complications arise. It was neglected in this case.

Case 37. H. W., female, seven years of age.

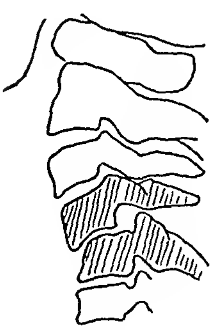

Fig. 23-A

Case 36. April 25, 1930. Dislocation of the fourth cervical vertebra on the fifth.

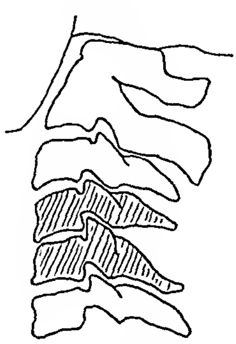

Fig. 23-B

Case 36. August 23, 1930. Four months after manipulation. Loss of intervertebral disc.

June 1933: The patient underwent a double mastoid operation. The head was in the torticollis position when the patient came out of the anaesthesia. Preoperative roentgenograms were said to have showed a normal spine. Postoperative roentgenograms showed a dislocation of the first cervical vertebra on the second.

April 1934: The patient entered Hospital X and the following report was made: "Hands off. Manipulation would be fatal."

May 1934: The patient was admitted to the Massachusetts General Hospital. Treatment consisted of manipulation, resulting in clinical correction without any demonstrable change in the roentgenogram. The patient was immobilized in plaster for two months

and a leather collar was worn for two months, followed by a Thomas collar for an additional two months.

April 1935: Some asymmetry of the neck and limitation of motion were observed, but there were no symptoms.

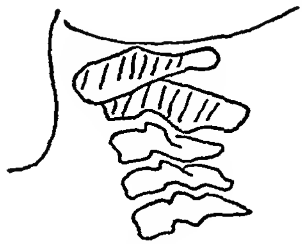

FIG. 24-A

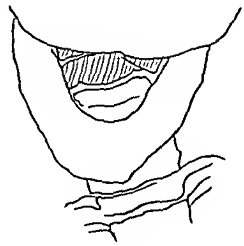

FIG. 24-B

Case 37. May 23, 1934. Dislocation of the first cervical vertebra on the second, eleven months after injury.

The opinion of Hospital X, one of the best-known hospitals in the country, is typical of the general feeling about these injuries. However, even after eleven months, clinical improvement can be attained.

CONCLUSIONS

1. Fractures and dislocations of the cervical spine should be reduced at once, just as are similar injuries elsewhere in the body.
2. Fractures are more serious than dislocations, and are more liable to be fatal or to be accompanied by irreparable cord or nerve damage.
3. Dislocations are very rarely fatal. Their reduction is not dangerous. They will not recur if properly treated.
4. Fixation after reduction either of a fracture or of a dislocation must be complete and of long duration.
5. Early complications cannot be avoided. · Proper treatment begun early will lessen their permanent effects.
6. Late complications are usually due to lack of early treatment and to inadequate fixation.
7. Operation is rarely indicated except to relieve late cord symptoms.

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NAVICULAR-CUNEIFORM ARTHRODESIS FOR FLAT-FOOT

An End-Result Study

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In 1931 Hoke described navicular-cuneiform arthrodesis as an operation which he had used since 1923 in the treatment of extremely relaxed flat feet. As the result of personal communications with Hoke, the operation had been done at the New York Orthopaedic Dispensary and Hospital upon nine patients previous to 1931, the earliest in 1927, and, following Hoke's favorable report, it has been carried out more frequently. By the end of 1934, seventy-two patients had had navicular-cuneiform arthrodeses for flat feet. The purpose of this article is to present primarily an end-result study of these seventy-two patients and a brief discussion of the actions of the long muscles of the foot.

The factors concerned in the maintenance of the normal longitudinal and transverse arches of the foot are the shapes of the bones of the foot, the strong ligaments which bind them together and limit their motions, and the properly balanced and synchronized actions of the long muscles. Abnormalities in any one of these factors, particularly in a growing foot, will produce abnormalities of the arch. The first two will not be discussed, and conceptions as to the relative importance of some of the last may vary.

The long muscles of the foot have been carefully studied by many observers and their actions and relative and actual power estimated and calculated. All will probably agree that a strong or contracted gastrocnemius has a detrimental effect upon the longitudinal arch, that a weak or paralyzed gastrocnemius will produce a cavus foot of the calcaneus type, and that the tibialis posterior, the peroneus longus, and the flexor hallucis longus are the principal arch-elevating muscles. These muscles, acting synergistically, supply powerful opposition to the arch-depressing action of the gastrocnemius, particularly as the heel is raised and weight is transferred to the forefoot in walking.

Many may not agree with the following conception of the action of the tibialis anterior. The author believes that it has no arch-elevating or supporting value for the following reasons:

1. It inverts or supinates the forefoot on the rearfoot, producing one of the elements of flat-foot.

2. It elevates the first metatarsal head and the anterior limb of the medial longitudinal arch, directly opposing the action of the peroneus longus, and produces a lowering of the medial longitudinal arch.

3. In walking, it contracts only during the swing phase of the step and for the instant of heel weight-bearing as the advanced foot is put to

the ground and the forefoot is lowered. When three-point weight-bearing is reached, and as weight moves forward to the forefoot, putting the greatest strain on the arch, the tibialis anterior is relaxed.

4. When it acts against a contracted gastrocnemius, or attempts to dorsiflex the foot against superimposed body weight, it throws a strain on the longitudinal arch.

Further, since each of the actions of the tibialis anterior produces one of the elements of flat-foot, the writer believes that weakness or paralysis of this muscle alone, particularly in a growing foot, is an important factor in the production of an exaggerated arch or claw-foot, the mirror-image of flat-foot.

Navicular-cuneiform arthrodesis, usually combined with a lengthening of the Achilles tendon, is a worth-while surgical procedure in the treatment of properly selected cases of flat-foot. The benefit derived from the operation is only the correction by arthrodesis of an existing sag or relaxation at the navicular-cuneiform joint, plus the temporary removal of the arch-depressing action of the calf by lengthening of the Achilles tendon.

This study of seventy-two patients upon whom the operation was performed prior to 1935 has shown that it has definite limitations and that it is not a cure-all for relaxed flat feet.

Each of the seventy-two patients, except six, had both feet operated upon, making a total of 138 feet operated upon. There were twenty-nine males and forty-three females, ranging in age from seven to thirty-three years. The average age at the time of operation was fourteen years, and we believe the early adolescent years from ten to fifteen to be the ideal time for the operation.

The preoperative complaint was of deformity (flat-foot) only in thirteen patients, deformity and fatigue in thirteen, and deformity with pain and fatigue in forty-six. Preoperative conservative treatment had been used in some instances for as long as ten years.

Some degree of contracture of the gastrocnemius was present in sixty-five patients, the dorsiflexion of the foot being limited at from 95 to 130 degrees, and in most patients at about 100 degrees. Lengthening of the Achilles tendon was done some months previous to the navicular-cuneiform arthrodesis in two patients, at the same time as the arthrodesis in sixty-one, and three weeks following the arthrodesis in six.

The technique of the operation was essentially that described by Hoke. In many instances, however, only the medial cuneiform was included in the arthrodesis, instead of the medial and the middle cuneiforms. In the end-result examination no difference could be found attributable to this fact alone. Postoperative treatment consisted of bed rest with plaster boots for from six to eight weeks and physiotherapy and the wearing of metal arch supports for from three to six months.

Recently we have been able to see forty-six of the seventy-two patients in a special follow-up study, including clinical and roentgenographic

examinations. This represented eighty-seven of the 138 feet operated upon. Most of the remaining twenty-six patients were seen at least one year after operation, so that a study of their charts and roentgenograms was considered valuable. Since in the final analysis each group coincided very closely, they are all included in this report. Considering each foot as to cosmetic, anatomical, and functional end results, we found that there were thirty, or 21.8 per cent., with an excellent result; forty, or 29 per cent., with a good result; and thirty-four, or 24.6 per cent., with a fair result; and the same number with a poor result. In other words, there were approximately 50 per cent. with satisfactory results and 50 per cent. in which the outcome left much to be desired,—in one-half of the latter, the results were definitely poor.

The thirteen patients (twenty-three feet operated upon) who before operation had complained of flat feet without symptoms showed at the last examination three feet anatomically excellent, nine good, seven fair, and four poor. All of these patients continued symptom-free except one who had occasional pain in the longitudinal arch, and two who had pain over the Achilles tendon. In one of the latter cases the tendon had pulled out at the site of the lengthening, resulting in a calcaneus deformity. This was the only patient in the entire series in whom such an event occurred, and she had had a previous lengthening of the tendon many years earlier.

The thirteen patients (twenty-six feet operated upon) who had complained of flat feet with fatigue showed two feet anatomically excellent, five good, ten fair, and nine poor. Nine patients no longer had fatigue; two continued to have fatigue; and two complained of fatigue and moderate pain at the site of the arthrodesis.

FIG. 1

Normal lateral standing view of left foot. Line *1* is drawn through the center of the navicular perpendicular to its articular surfaces; *2* is drawn parallel to the long axis of the first metatarsal; and *3* is drawn parallel to the long axis of the neck of the talus.

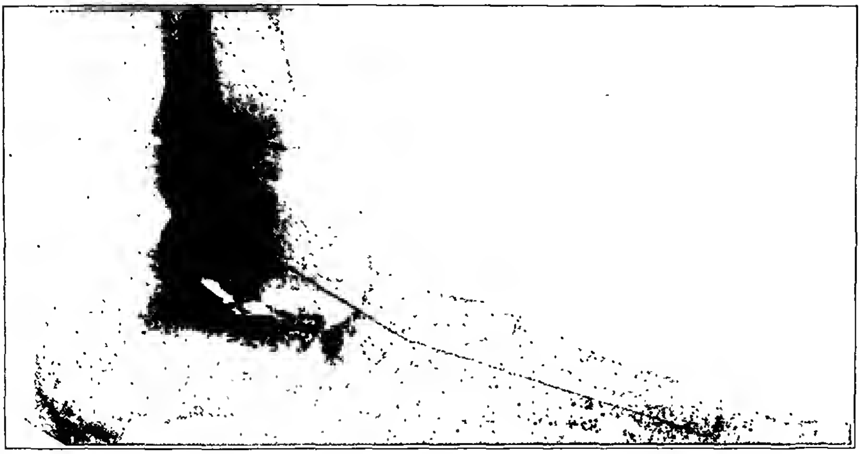

Fig. 2-A

J. G., aged thirteen years, an ideal case. Preoperative roentgenogram of the left foot, taken on April 27, 1934, showing no sag at the talonavicular joint and a sag of 15 degrees at the navicular-cuneiform joint.

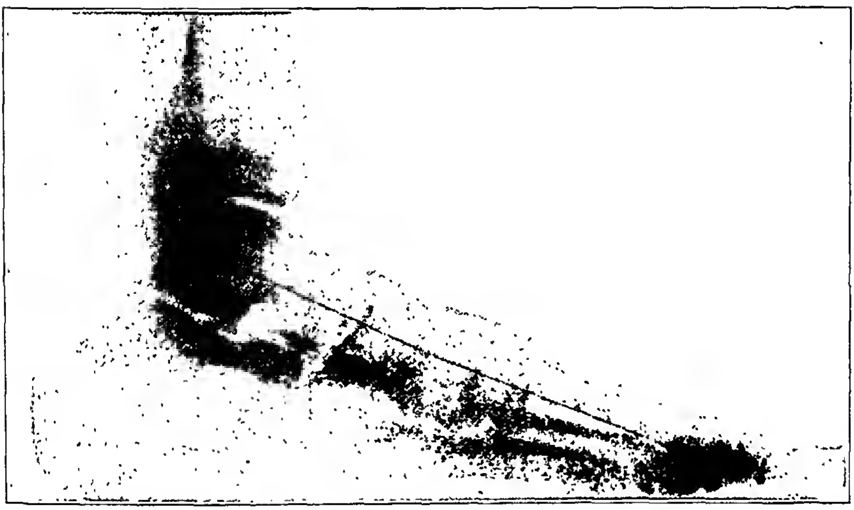

Fig. 2-B

J. G. Roentgenogram of the left foot, taken on January 6, 1936, one year and eight months after operation. The arch is much improved; a slight navicular-cuneiform sag persists; fusion is solid.

The forty-six patients (eighty-nine feet operated upon) who had complained of flat feet with pain and fatigue showed nine feet anatomically excellent, thirty-one good, twenty-eight fair, and twenty-one poor. Twenty-six patients no longer had either pain or fatigue; twelve still had fatigue but no pain; and eight still had pain in the longitudinal arches, in two of which the pain was worse than before operation.

Six patients had navicular-cuneiform arthrodesis at one operation, followed in three weeks by a second operation for lengthening the Achilles tendon. The end results in these patients showed four excellent feet,

FIG. 3-A

W. S., aged ten years, a case of a plantar-flexed talus. Preoperative roentgenogram of the right foot, taken on April 7, 1934, showing a marked sag (27 degrees) at the talonavicular joint. There is no sag at the navicular-cuneiform joint. Lengthening of the Achilles tendon was done on April 12, 1934, followed by a navicular-cuneiform arthrodesis on November 4, 1934.

FIG. 3-B

W. S. Roentgenogram of the right foot, taken on December 28, 1935, thirteen months after arthrodesis, showing flat-foot and a sag at the talonavicular joint.

four good feet, two fair, and two poor. The patients in this group with a poor result had plantar flexion of each talus, a condition we now consider a contra-indication to navicular-cuneiform arthrodesis. Where feasible, we now prefer to perform the arthrodesis at one operation and the tendon-lengthening at a second operation three weeks later, for, in order to obtain adequate correction at the navicular-cuneiform joint, the first metatarsal head must be well depressed or plantar-flexed. This will not be accomplished if any upward pressure is made on the forefoot in attempting to bring the foot to 90 degrees of dorsiflexion, the position desired after

lengthening the Achilles tendon. Even careful use of the Hoke molded-sole plaster technique has not always assured that no upward pressure would be exerted on the first metatarsal head, with consequent inadequate correction at the navicular-cuneiform joint and production of a certain amount of fixed supination of the forefoot on the rearfoot.

Roentgenograms taken preoperatively, immediately after operation, and at the last examination were studied. The lateral standing view was found to be most useful, though often misleading if not a true lateral exposure, and often showed an arch better than would be expected from clinical examination. In each case measurement of the actual amount of sag at the navicular-cuneiform and at the talonavicular joints was attempted. (See Figure 1.) Preoperatively there was an average sag of 10.5 degrees at the navicular-cuneiform joint, and of 6 degrees at the talonavicular joint. At the last examination the average sag at the navicular-cuneiform joint was 0 degrees and 5 degrees at the talonavicular joint. (See Figures 2-A and 2-B.)

The appearance of the roentgenograms left reasonable doubt as to the presence of solid bony union at the site of the navicular-cuneiform arthrodesis in eighteen, or 13 per cent., of the 138 feet operated upon. In ten of these the results were poor, at least in part attributable to the failure of union; however, in eight the results were fair or better, fibrous union of sufficient strength to maintain the proper relationship of the bones probably having occurred.

We were particularly interested in the analysis of the twenty-three patients (thirty-four feet operated upon) with poor end results. We found the following factors which we believe had definite unfavorable effects upon the end results:

1. Plantar flexion of the talus (Figs. 3-A and 3-B); that is, too great relaxation and sag at the talonavicular joint.
2. Too great generalized relaxation of the foot, making arthrodesis of one joint and correction of alignment at this joint insufficient to restore a satisfactory arch.
3. Obvious deformity of one or more of the tarsal bones.
4. Inadequate correction or no correction obtained at operation, resulting in a persisting and fixed amount of supination of the forefoot on the rearfoot.
5. Failure of the operative fusion; in ten cases the results were poor, in eight they were fair or better.
6. Obesity of the patient, with excessive strain on the arches of the foot.
7. Arthritis in the tarsal joints.
8. Stretching or pulling out of the Achilles tendon (one foot).

The end result was the same in both feet in fifty-six of sixty-six patients who had both feet operated upon. Since in these patients the operation was performed by different surgeons, it would seem that the proper selection of the patient is of much greater importance than minor

differences in technique. We now consider the following conditions ideal for navicular-cuneiform arthrodesis:

1. The patient should be in the early adolescent years of life, and should not be obese.

2. The foot should not be severely relaxed or severely pronated, as arthrodesis of one joint in this type of foot is insufficient to restore a good arch.

3. The lateral roentgenogram, with the patient in the standing position, should show a definite sag or relaxation at the navicular-cuneiform joint, and only a slight sag, if any, at the talonavicular joint.

4. There should be no definite deformity in any of the tarsal bones.

5. There should be no arthritis in the foot or the ankle.

6. If the navicular tubercle is large, or if an os tibiale externum is present, it should be removed, as this greatly improves the cosmetic result and possibly also the functional result by slightly altering the pull of the tibialis posterior.

SUMMARY

Of 138 cases of flat-foot, treated by navicular-cuneiform arthrodesis during the years 1927 to 1934 inclusive, the end results were excellent in thirty, good in forty, fair in thirty-four, and poor in thirty-four.

From this study it would seem that, in carefully selected cases of flat-foot, navicular-cuneiform arthrodesis is a worth-while surgical procedure.

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MYOSITIS OSSIFICANS PROGRESSIVA

With Report of a Case

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The literature on myositis ossificans has recently been reviewed by Mair. Recent papers on the differential diagnosis [4, 9], on therapeutic methods [6, 10, 11], on pathogenesis and histogenesis [1, 12], and on the roentgenographic findings [3] may also be consulted. The nature of the disease remains obscure, and the therapy disappointing.

Recent clarification of the state of calcium in the blood [8] has added interest to the study of abnormalities of calcification and ossification. On the other hand, the finding of these authors that, in certain diseases associated with gross abnormalities in the skeletal system, of which from the data here presented myositis ossificans appears to be one, the calcium in the blood is neither qualitatively nor quantitatively changed from the normal apparently makes it necessary to search further for the pathological physiology of this disease.

Following the lead of Guyatt, Kay, and Branion, who employed beryllium carbonate to induce rickets in rats, one of the authors, at the suggestion of Dr. F. C. McLean, attempted similar procedures in a human subject in a case of this disease. No record has been found so far in the literature that this chemical has ever before been employed on a human.

CASE REPORT

Personal History

The patient is a white female, twenty-three years old, weighing eighty-six pounds. No untoward complications were noted during the mother's pregnancy, and no instruments were used at delivery. The birth weight was seven pounds, and the infant was breast fed. The patient had the usual childhood diseases. Two brothers had no physical or mental defects. One brother had drooling from the mouth and a slight impediment in speech. He died at the age of nine; the cause of his death was not known. The only abnormality noted during the patient's infancy and early childhood was the inability to move the great toes of both feet.

When five years of age, the patient fell from a height of four feet and the cervical spine was severely injured. She was unable to turn her head after this injury, and later the right elbow became stiff. Ankylosis of many joints developed between the ages of six and nine years. At the age of twelve years she sustained a fracture in the distal end of the right radius and was admitted to St. Andrew's Hospital, Murphysboro, Illinois. A roentgenographic examination of the torso was made, which showed extensive ossifications in the musculature and in other extraskeletal tissues. At the age of sixteen the patient fell from a fire escape and was unconscious for three days. No fractures were noted. At the age of eighteen the patient was in a railway accident. The exact injury sustained is unknown, but she was unconscious for ten hours. She has spent the past twelve years of her life in charitable institutions. Her crippled condition caused her to

be dependent on nursing care and on one occasion, when a ward of a county farm, she took roach powder with suicidal intent.

The patient was admitted to the Anna State Hospital for the mentally ill, at Anna, Illinois, on January 17, 1934. No psychotic behavior was noted during her entire period of hospitalization.

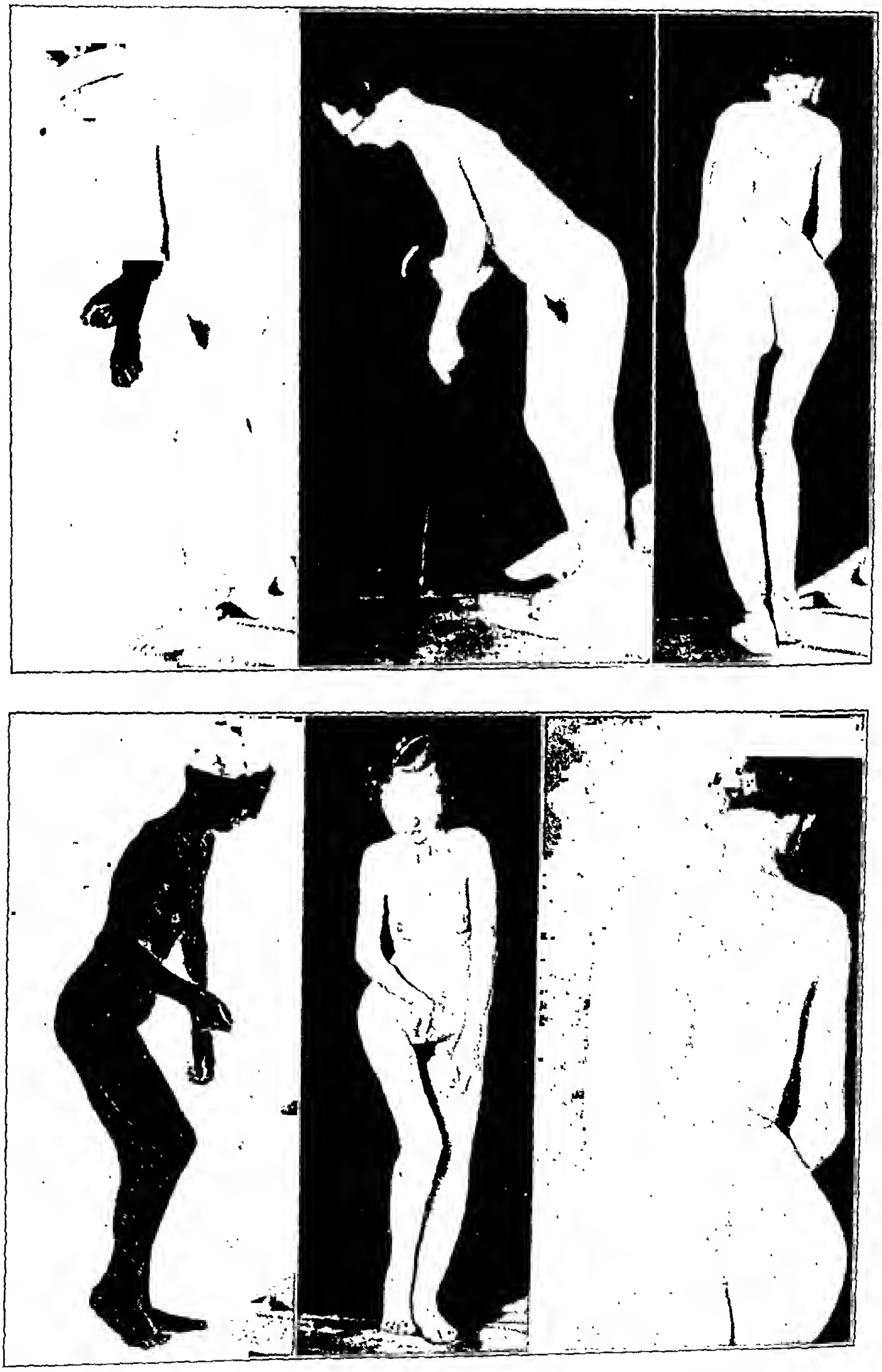

Fig. 1

Family History

This was essentially negative. Her father met with an accidental death, and her mother died of an unknown cause during the climacteric period. There were no abnormalities in either parent.

Physical Examination

The patient was four feet, ten inches tall in a position of flexion. She could not stand erect. (See Figure 1.) She was ill-nourished, markedly deformed, and unable to flex her hips so that she could sit. The mucous membranes and conjunctivae were pale. She was unable to open her mouth. There was a hard palpable mass in the thyroid gland, two by two centimeters in size. The pupils reacted to light and to accommodation. There was a marked blowing first sound at the apex. The left chest was depressed anteriorly from the level of the seventh rib. Expansion was limited on both sides and breathing was abdominal in type. Satisfactory palpation and percussion of the lungs were not possible because of the abnormal thoracic cage. No cough or expectoration was noted. A slight elevation of temperature occurred irregularly in the afternoon. There was no evidence of pulmonary lesion. The digestive, urinary, and reproductive systems were negative. The superficial reflexes were exaggerated. Deep reflexes were diminished bilaterally. Organic reflexes were intact. There were no disturbances of taste. The sense of smell was normal. Hearing and vision were normal. Marked dermographia was noted. The outstanding abnormalities were confined to the skeletal and muscular systems, in the form of ankyloses, exostoses, distortions, and calcifications, and are represented by Figures 2, 7-A and 7-B, taken from tracings of roentgenograms.

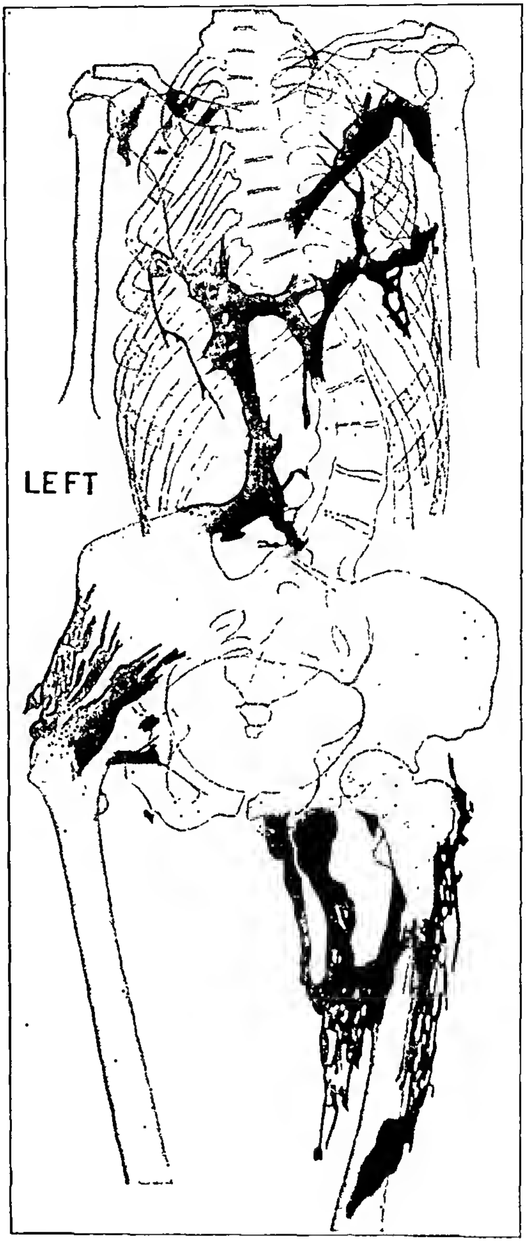

FIG. 2

Laboratory Findings

Blood examination:

Red blood count	4,500,000 to 4,200,000
Hemoglobin (Sahli)	85 per cent. to 75 per cent.

White blood count	9,000 to 5,000
Differential count (100 counted)	
Polymorphonuclear leukocytes	66 per cent. to 56 per cent.
Lymphocytes	28 per cent.
Monocytes	5 per cent.
Basophiles	1 per cent.
Eosinophiles	3 per cent. to none
Blood platelets	150,000
Coagulation time	4 minutes
Bleeding time	5 minutes
Blood pressure	110/70

Kahn and Wassermann tests on blood were negative.

Spinal puncture was not done because of the patient's condition.

The sedimentation test showed a slight hastening in the precipitation of erythrocytes.

Urine: The volumes of the twenty-four-hour specimens taken for a period of a week averaged 1,625 cubic centimeters and were essentially negative except for one plus albumin, occasional pus cells, specific gravity of 1.026 to 1.015 with a calcium oxide value of 0.087 grams, and 1.40 grams of inorganic phosphorus (phosphoric acid) for daily volume. The urine was light green, cloudy, and of putrid odor.

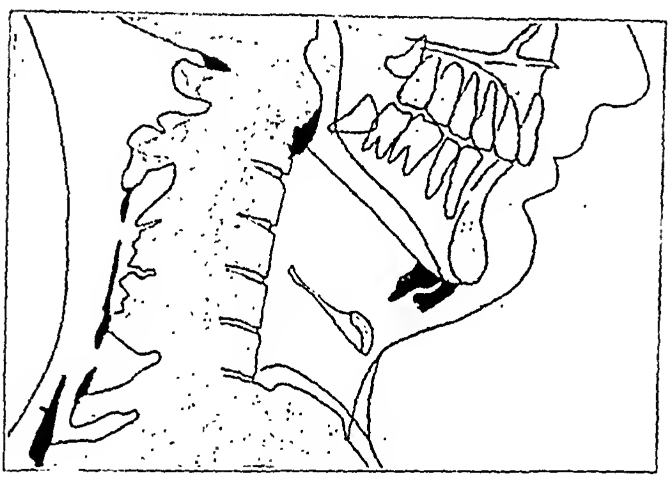

Fig. 3

Sputum: The sputum was scanty. Repeated examinations for acid-fast bacilli were negative.

The basal metabolic rate could not be obtained because of the patient's inability to open her mouth sufficiently.

Diagnosis and Differential Diagnosis

The following four diseases should be considered primarily: (1) myositis fibrosa; (2) Pott's disease; (3) multiple exostosis; (4) calcinosis universalis. The differential points of the first three from myositis ossificans progressiva are given by Mair and as a rule offer no difficulty. The differentiation from the last disease, however, is not so simple. Nevertheless, in calcinosis universalis the following six points, which were advanced by Mair, should be of value:

1. Lesions of calcinosis universalis are harder and contain a greater proportion of calcium salts than does the fully formed bone.
2. The nodules discharge chalky homogeneous debris.
3. The disease appears later in life and is more common in females.
4. Generally there are present no congenital abnormalities such as an absence of the interphalangeal joints of the great toes (Fig. 6) and microdactylia which occurs in 75 per cent. of the cases of myositis ossificans progressiva.
5. The tendons and fascia are never involved.
6. These calcium deposits apparently have the spontaneous power of reabsorption.

There are a few organs, which contain striated muscle fibers, that are never involved in the abnormal ossifications. Most significant among them may be mentioned the diaphragm, the tongue, and the sphincters.

The diagnosis of myositis ossificans progressiva was made in our case after a thorough examination of roentgenograms which extended over a period of eleven years. (See Figures 7-A and 7-B. Compare the lumbar spines and iliac crests.) The diagnosis was

further strengthened after special studies of blood serum and repeated determinations of calcium and inorganic-phosphorus content had been made.

A biopsy was performed on the muscle tissue in November 1934 in order to determine any alterations or abnormalities. The tissue was removed from the left biceps, fixed in 10-per-cent. formaldehyde solution, and studied in the pathological laboratories of Rush Medical College and the Illinois Research and Educational Hospital. Both laboratories reported that there was nothing abnormal either in the striations or in other respects. Considerable induration and only a slightly increased opacity to x-rays had developed at the site of the biopsy six weeks after it was performed.

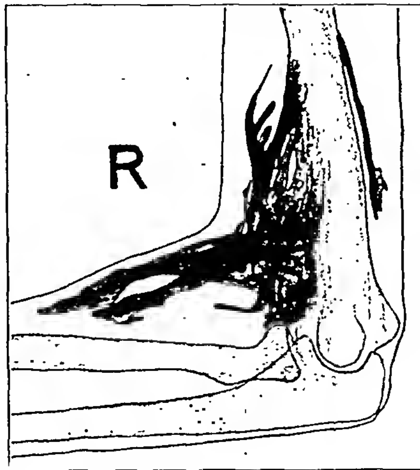

FIG. 4

In May 1935 a biopsy of abnormal growth from bone tissue was performed and specimens were sent to the same institutions in order to determine whether these growths were calcifications or ossifications. In the former case, the diagnosis of calcinosis universalis would be indicated, and, in the latter, that of myositis ossificans progressiva. This point was positively settled by the following report after a thorough microscopic study of the bone tissue: "The sections contain

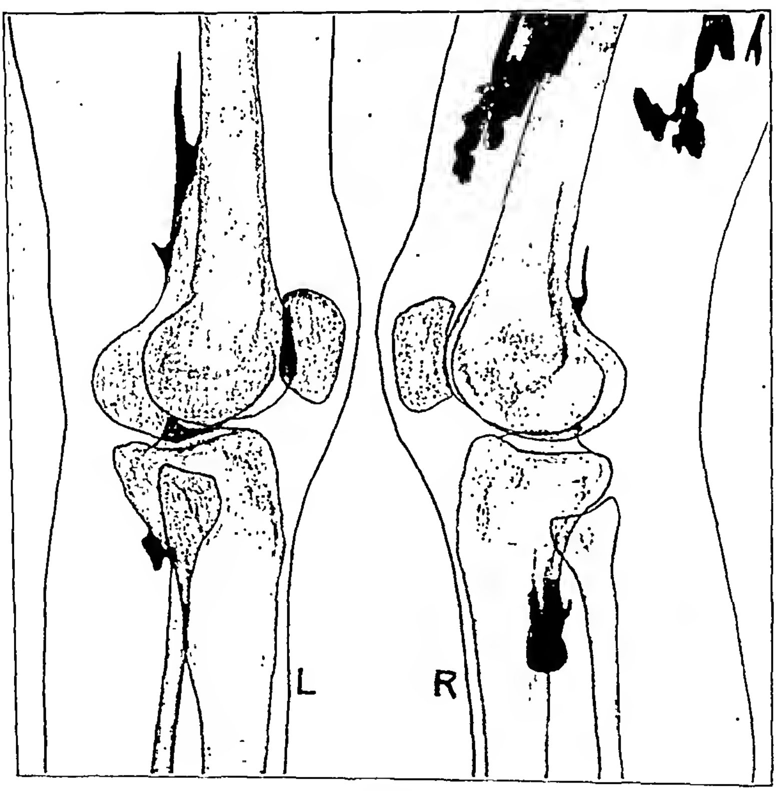

FIG. 5

atrophic striated muscle fibers, and islets of young bone. The diagnosis is myositis ossificans." This diagnosis was further confirmed at the University of Chicago Clinics. The availability of roentgenograms for study over a period of eleven years also added evidence of the presence of myositis ossificans progressiva.

Special Studies

Special features of the case were studied with the cooperation of the two laboratories mentioned. All routine chemical analyses of the blood yielded normal values. Repeated analyses of serum gave values for calcium ranging from 9.6 to 10.7 milligrams per 100 cubic centimeters, and for inorganic phosphorus from 3.4 to 4.2 milligrams per 100 cubic centimeters. Direct observation of calcium-ion concentration of the serum by the method of McLean and Hastings gave a value of 4.5 milligrams per 100 cubic centimeters, in close agreement with a value of 4.65 milligrams as calculated from total calcium and total protein. The serum was found to have a phosphatase content of 0.22 units.

All examinations of the blood having given normal results, attempts were made to modify the calcium-phosphorus relationships. For one month, alkaline sodium phosphate, twelve grams per day, as used by Brooks in the treatment of calcinosis universalis, was administered without appreciable influence either upon serum calcium or upon inorganic phosphorus. Following a rest period, beryllium carbonate, found by Guyatt, Kay, and Branion to cause a marked reduction in the inorganic phosphorus of the serum when fed to rats, was administered, first at the rate of three grams per day and later at the rate of six grams per day, a total of 200 grams being given without untoward symptoms. No appreciable change in serum calcium was observed. Serum inorganic phosphate was 2.9 milligrams per 100 cubic centimeters after two weeks and 3.4 milligrams per 100 cubic centimeters at the termination of the period of observation. The final sample of serum was tested for ability to produce calcification *in vitro* in rachitic bone slices from the rat, with negative results. There was no roentgenographic evidence of decalcification, either in the skeleton or in the abnormal deposits at this time, and the area in which a biopsy had been performed actually showed evidence of a slight deposit of calcium during the period of medication.

It was not to be expected that the administration of alkaline sodium phosphate, or of beryllium carbonate, over the relatively short periods during which they were given, would produce recognizable roentgenographic changes in the skeleton or in the abnormal bone deposits. It was hoped, however, in the case of beryllium carbonate, which apparently acts by forming an insoluble beryllium phosphate in the intestinal tract, that the inorganic phosphate in the blood could be reduced sufficiently in concentration to delay or to prevent further calcification, possibly even with some decalcification of existing lesions. There was, naturally, no *a priori* reason to believe that any such effect would act differentially upon normally and abnormally situated bone. Failure to produce any significant lowering of the inorganic phosphate of the serum may probably be attributed to insufficient dosage in relation to the amount of phosphate in the diet,

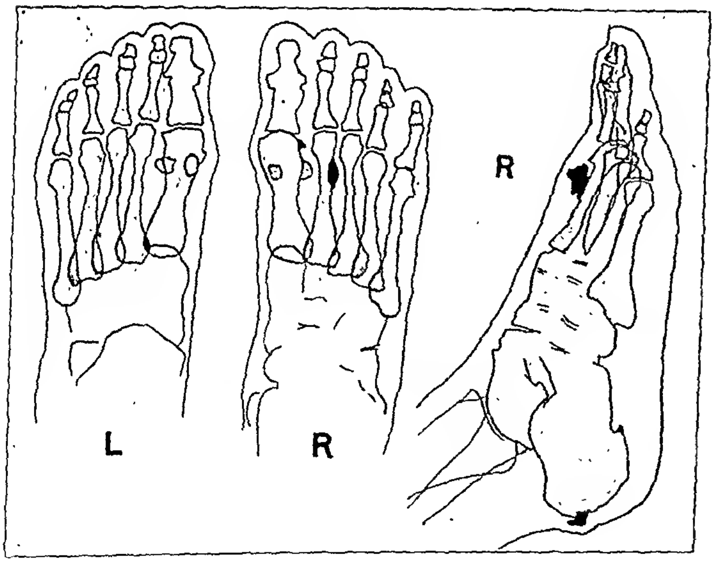

FIG. 6

but since it was impracticable to control the diet no data were secured on this point.

This case is of interest for the following reasons:

1. There are extensive pathological changes throughout the skeletal and muscular systems of the body, not excluding the lower extremities. It is also interesting to note that the usual span of life which is from ten to fifteen years does not hold good here, although the exact age of onset could not be determined from the history. It is, however, indisputable that there was a congenital absence of interphalangeal joints in each great toe (Fig. 6).

2. The availability of records, including roentgenograms, over a period of more than a decade, which clearly demonstrate the chronological progression of the disease in the musculature, is of immense help.

3. There have been extensive chemical studies in an attempt to throw some light on the pathological physiology of the disease, with uniformly negative results.

4. This is apparently the first case in which beryllium carbonate has been used on a human subject. The results are at present disappointing. The authors are hopeful, however, that favorable results may be obtained in human beings if the subjects are available prior to the full development

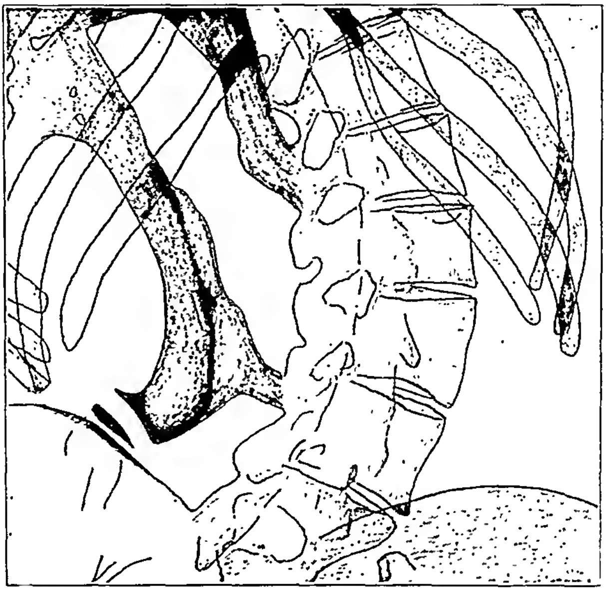

Fig. 7-A
1924

Fig. 7-B
1935

of the osseous system, at a period comparable to the stage in which this chemical was effective in producing osteomalacia in young rats.

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EXTRA-ARTICULAR ARTHRODESIS OF THE SHOULDER

BY FRANK E. CURTIS, M.D., AND HIRA E. BRANCH, M.D., DETROIT, MICHIGAN

From the Children's Hospital, Detroit

One would hesitate to report two cases of extra-articular fixation of the shoulder joint for tuberculosis in children were it not for the comparative infrequency of this lesion. Whitman states that tuberculosis of the shoulder joint occurs in not more than 2 per cent. of all cases of joint tuberculosis and that it is more frequent in adults than in children. In the majority of the cases the primary disease is in the head of the humerus. It rarely originates in the scapula and only occasionally does it appear to be primarily synovial.

In the October 1933 issue of *The Journal of Bone and Joint Surgery*, R. Watson Jones described an operative procedure to obtain extra-articular arthrodesis of the shoulder joint. He reported two cases of such arthrodesis in adults and one other case combining an extra-articular and an intra-articular arthrodesis. At the time this article appeared we had one case of tuberculosis of the shoulder joint in a child, which required operation. The joint was operated upon and fused according to the extra-articular method described by Jones. In a short time ankylosis in a good functional position of abduction was obtained and the result was very satisfactory. Since that time we have had one other case of tuberculosis of the shoulder joint in a child. This joint was operated upon by the same method with an equally good result. It is now three years since the first operation and two years since the second operation.

FIG. 1

Case 1. Before operation.

FIG. 2

Case 1. After operation.

FIG. 3
Case 2. Before operation.

FIG. 4
Case 2. After operation.

The technique of the operation as described by R. Watson Jones will not be reviewed, but our two cases follow.

CASE REPORTS

CASE 1. S. S., a male, aged eleven years, first entered the Clinic in 1931, due to a deformity of the spine which clinically and roentgenographically had the appearance of tuberculosis involving the ninth, tenth, and eleventh thoracic vertebrae. The patient was treated on a Bradford frame in a sanatorium for over two years and then, wearing a back brace, was up and about. In 1933 he reentered the Clinic, due to a stiff shoulder which was in the adducted position and had the appearance of tuberculosis.

In October 1933 an extra-articular arthrodesis was done according to the technique of R. Watson Jones. The arm was held in 75 degrees of abduction in a plaster spica and later in an abduction brace for eleven months. The brace was then gradually removed. In December 1935 the shoulder was solidly ankylosed in this position of abduction. The child is now able to get his hand on the top of his head easily and the scapula allows the arm to drop to the side.

It is interesting to note that this patient has had a flare-up of the spinal lesion which was treated without operation and which will now require a fusion operation of the spine.

CASE 2. M. M., a female, aged ten years, was first examined in 1935 with a history of having been unable, for twelve months prior to admission, to raise her hand to her head and of increasing stiffness. The arm was held close to the side and there was marked limitation of motion. Clinically and roentgenographically the lesion had the appearance of tuberculosis.

In June 1935 an extra-articular arthrodesis was done according to the technique of R. Watson Jones. The arm was held in 70 degrees of abduction in a plaster spica for three months and then a steel abduction splint was applied and gradually removed. The shoulder is solidly ankylosed in this position of abduction; no pain is present, and the patient is able to place her hand on the top of her head. The roentgenograms show bony union.

CONCLUSIONS

A study of the two cases of tuberculosis of the shoulder joint in children, treated by the Jones extra-articular arthrodesis, yields the following conclusions:

1. The operation is well adapted for fusing a tuberculous shoulder in a child and gives firm bony ankylosis with little reaction on the part of the patient.
2. Bony fusion is speedily accomplished.
3. The operation should be done when the process is quiescent.
4. The cosmetic and functional results following the operation are good.
5. The epiphyses of the bones involved are not destroyed by the operation.
6. To date there has been no recurrence of the symptoms in the two shoulders operated upon by this method.

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A COMPLETE COMPOUND SUBASTRAGALAR DISLOCATION OF THE TARSAL BONES

BY DUNLAP P. PENHALLOW, M.D., F.A.C.S., WASHINGTON, D. C.

The following case of a complete compound dislocation of the tarsal bones from the astragalus is believed to be of sufficient rarity to justify its being reported, especially as there were no associated fractures.

E. P., a white male, aged twenty-five, an ironworker, was injured on May 9, 1935. He stated that, while working on a ladder, he had been struck by an iron bar which had, knocked him off of the ladder. He had landed on his right ankle, and had turned it. He was immediately taken to the hospital where he was seen by the author shortly after admission.

Examination showed the patient to be a rather large and well-developed young white male. He did not appear to be in any great pain, and there was no shock. General physical examination was essentially negative. Examination of the right ankle showed a lacerated wound, four inches in length, extending horizontally just below the external malleolus. The foot was in pronounced inversion which was so marked that the plantar aspect was rotated over 90 degrees. The articular surfaces of the astragalus were completely exposed, due to the marked rotation of the foot. The scaphoid and the other anterior tarsal bones and the metatarsals were completely displaced from the astragalo-scaphoid articulation, while the os calcis was dislocated from the astragalocalcaneal articulation. (See Figures 1-A, 1-B, and 2.) Circulation of the foot was good and the dorsalis-pedis artery could be felt pulsating.

FIG. 1-A

Dislocation of the os calcis and of the anterior tarsal bones from the astragalus. (See also Fig. 1-B.)

The patient was taken to the operating room very shortly after admission, and, under general anaesthesia, the wound was thoroughly cleansed and irrigated. All devitalized and unduly torn tissues were excised and the dislocation was reduced with very little difficulty. No attempt was made to suture the ligaments, as these were rather badly torn. The external wound was closed rather loosely with interrupted sutures and without drainage. A large dressing was used and a cast was applied from the toes to the tibial tubercle with the foot slightly everted. Roentgenograms (Figs. 3-A, 3-B, and 3-C), taken after the operation, showed a complete reduction of the dislocations.

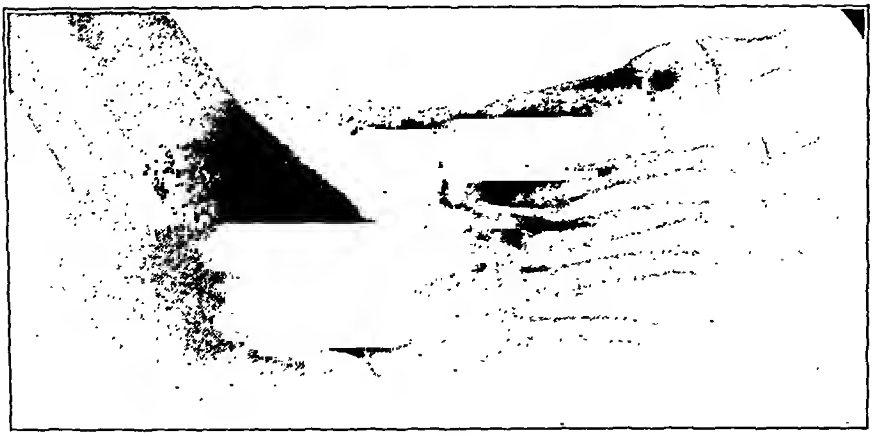

FIG. 1-B

FIG. 2

Lateral roentgenogram, showing a complete subastragalar dislocation of all of the tarsal bones.

Following the operation, the patient presented an uneventful convalescence. There was no elevation of temperature and at no time was there any evidence of infection. The patient was discharged from the hospital on May 20, 1935. The cast was continued for a little over four weeks following his discharge from the hospital, after which time he was furnished with a support and was allowed to bear some weight on the foot, but he was still using crutches. Physiotherapy was given three times a week and the patient was

gradually allowed to bear more weight on the foot. He finally returned to work in the early part of August. At the time of his return to work he walked without any limp. Dorsiflexion and plantar flexion were essentially normal as compared with the left ankle.

Fig. 3-A

Fig. 3-B

Fig. 3-C

Roentgenograms after reduction.

Active inversion of the foot was essentially normal, but there was slight restriction on active eversion. The wound was well healed, and there appeared to be practically no functional disability.

This case is presented simply as a case of a complete dislocation of the tarsal bones from the astragalus without any associated fractures, but complicated by an extensive, open, traumatic exposure of the articulating surfaces of the astragalus.

AN UNUSUAL FRACTURE-DISLOCATION OF THE TARSAL SCAPHOID WITH DISLOCATION OF THE CUBOID

BY DUNLAP P. PENHALLOW, M.D., F.A.C.S., WASHINGTON, D. C.

While it is true that fractures of the tarsal scaphoid do occasionally occur, and dislocations of single tarsal bones take place rather rarely, the author feels that the following case, which presents a combination of a fracture and a dislocation of the same bone, together with a partial dislocation of the cuboid bone, may be of interest.

J. S., a white male, aged thirty-four, a laborer, was injured on August 30, 1933. He stated that the rope which he was using to hoist some timber caught and knocked him off of the scaffold on which he was standing. He managed to keep hold of the rope and slid to the ground, a distance of seventy-five feet, striking with considerable force on both

Fig. 1-A

Fracture of the scaphoid and upward displacement of the upper fragment, also partial dislocation of the cuboid. (See Fig. 1-B.)

Fig. 1-B

Anteroposterior view, before reduction.

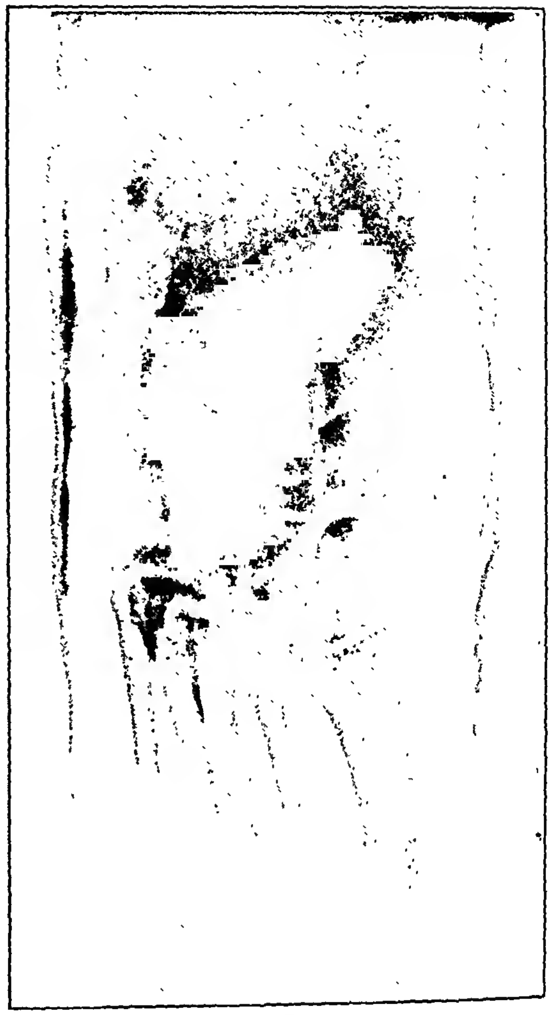

Fig. 2-A

Anteroposterior view. After reduction.

Fig. 2-B

After reduction, showing practically complete reposition of the fracture and of the dislocation of the scaphoid and of the cuboid. (See Fig. 1-A.)

feet. He was not rendered unconscious, but sustained multiple injuries for which he was taken to the hospital, where he was seen shortly after the accident.

On admission he was conscious and rational, but extremely nervous. Examination of the head was essentially negative, except for some superficial abrasions on the forehead and cheeks. The left elbow and both wrists and hands presented some superficial abrasions. Extensive abrasions were noted on the mesial aspect of the upper half of the left thigh, as well as over the inner aspect of the leg. There were numerous contused areas over the shoulders and back. With the exception of the right foot, which presented a marked deformity at the mediotarsal joint, there were no evidences of fracture. There was a marked pes cavus and the forefoot was inverted. Pronounced tenderness was present over the mediotarsal joint, and all motions of the foot were extremely painful. There was some thickening on the dorsal surface about the mediotarsal joint, but no crepitus could be elicited. The left foot was tender to palpation, but there was no deformity, and no signs of fracture or dislocation could be observed.

Roentgenograms of the left foot were negative. The right foot showed a partial dislocation of the tarsal scaphoid, associated with a fracture through the inferior and mesial portions of the bone with some separation of the fragments. There was also a partial dislocation of the cuboid. (See Figures 1-A and 1-B.)

The right foot was immobilized in a temporary splint, and on the following day, under general anaesthesia, the foot was manipulated. The dislocation could not be reduced by manipulation alone; reduction was finally accomplished by a combination of manipulation and the use of a heavy mallet, after the method of Cotton for fractures of the os calcis. This combination of methods appeared to be successful, as the deformity of the foot was corrected and the contour appeared to be essentially the same as in the left foot. Plaster was applied from the toes to the tibial tubercle, and the foot portion was molded well into the arch. Roentgenograms (Figs. 2-A and 2-B), taken immediately following the manipulation, showed good reduction of the fracture and also good reposition of the dislocation both of the scaphoid and of the cuboid.

The cast was continued for about four weeks, after which physiotherapy was started and the cast was continued for about three weeks more. The patient was then fitted with an arch support and was allowed to bear weight gradually on the foot. Convalescence was uneventful and the patient finally returned to work in March 1934. At that time he showed no deformity of the foot. There was very slight thickening about the mediotarsal joint, but the joint was flexible. Motions of the ankle were normal. There was neither swelling of the foot nor pain. The patient was fitted with a leather and felt arch support which he was instructed to use for a few weeks. At the time of his return to work there did not appear to be any functional disability. He was seen again after having been at work for a month. He showed no disability and had been able to carry on well with his work.

The interesting fact about this case is that this man slid and fell a distance of seventy-five feet and sustained only minor injuries, except for the fracture-dislocation of the tarsal scaphoid and the partial dislocation of the cuboid.

BENNETT'S FRACTURE OF THE THUMB

BY SIR WILLIAM I. DEC. WHEELER, LONDON, ENGLAND

Some years ago the author contributed a paper on the subject of Bennett's fracture of the thumb, from the point of view of a surgeon who had sustained this injury. Signs, symptoms, prognosis, and treatment were reviewed in detail. It is the purpose of this communication to record the end result approximately five and a half years after the injury.

The writer sustained a Bennett's fracture of the left thumb in July 1931, and it was then realized that permanent incapacity to carry on his profession might follow.

The fracture was reduced and held in the extended and abducted position by means of plaster-of-Paris in which a wire "gallows" was incorporated. About a fortnight later, when the writer was attempting to land a large fish with a small rod, the fragment slipped, and "the deformity was again obvious. . . . The thumb felt as if it could never again control a pair of scissors, as if the tying of a ligature would never be possible, and that the application of even the lightest forceps to a vessel was out of the question. Attempts to oppose the thumb to the other digits were fruitless, the only possible opposition was to the side of the first finger." No further attempt at reduction was made. It was ascertained by means of the fluoroscope that movements were not blocked by the fragment.

Occupational treatment consisted in the frequent immersion of the hand in a basin of hot water, at the bottom of which lay artery forceps, scissors, and ligatures. Daily attempts (very feeble at first) were made to open and to close the forceps, to tie ligatures,

FIG. 1

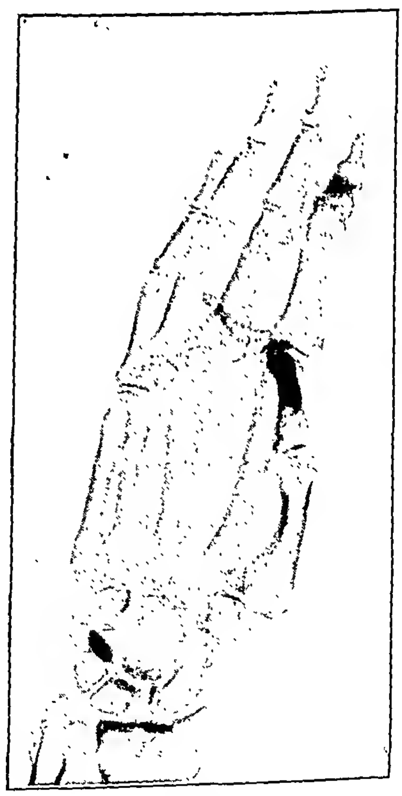

FIG. 2

Recent x-rays showing the amount of voluntary abduction and adduction. Firm bony union is present and there is some shortening, but no arthritic changes.

and to handle the scissors. Massage followed these immersions, and in the intervals the thumb was supported by a firmly applied adhesive elastic bandage. With this support and two pairs of rubber gloves, it was possible to undertake minor surgical operations after seven weeks' treatment. Pain and awkwardness persisted for about six months. After twelve months all disability had disappeared, and after five and a half years the thumb is perfect from a functional point of view. All the fingers can be opposed to the thumb with full force; there is no pain and no sign of arthritic change. The prominence of the subluxation in the "snuff-box" remains, and there is slight shortening. With the exception of a very slight limitation of abduction, movements are free and normal.

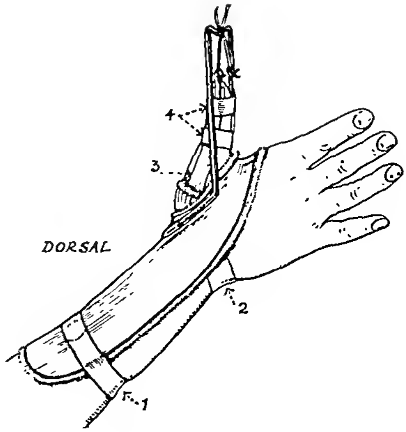

Fig. 3

Splint designed by the author for Bennett's fracture of the thumb. (*Courtesy of The Medical Press and Circular.*)

1: Strapping to fix splint to forearm;
2: Strapping under splint to keep pressure pad in position;
3: Portion of pressure pad protruding through opening in splint;
4: Longitudinal and circular extension straps.

It is well known that in some cases of this fracture the most perfect reduction may be followed by poor function and that the reverse is also true,—*i. e.*, excellent function may follow a poor reduction. Treatment by fixation and extension in plaster-of-Paris is suitable when the patient is within easy reach of facilities for the renewal of the splint should this become necessary. By whomever applied, plaster may fail in its purpose, and a reapplication becomes necessary. Under many familiar conditions plaster-of-Paris is best avoided in the treatment of this fracture and of many other common fractures.

As a result of his own experience, and with the knowledge that the splint recommended by Bennett was inefficient, the writer designed the splint shown in Figure 3.

This splint is a padded aluminum gutter with a large aperture at one end. From this opening a wire gallows projects in the position of an abducted thumb. An adhesive felt pad is placed over the site of the fracture, and the splint is applied to the lateral aspect of the forearm with the thumb projecting through the aperture. The fracture is reduced by manipulation and extension. The latter is maintained by tapes secured to the thumb by adhesive and tied tightly to the end of the gallows.

If the patient faithfully keeps the tapes taut, and if the splint is firmly bandaged in position or secured by plaster for about three weeks, the result is quite satisfactory. As a rule, fixation in a light plaster for an additional three weeks is desirable.

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CONSERVATIVE METHOD OF CORRECTING FLEXION DEFORMITY OF THE KNEE COMPLICATED BY POSTERIOR LUXATION OF THE TIBIA

BY M. THOMAS HORWITZ, M.D., PHILADELPHIA, PENNSYLVANIA

*From the Hospital for Joint Diseases *, New York, N. Y.*

From his successful employment of Haggart's method of skeletal traction for correcting flexion deformity of the knee complicated by posterior luxation of the tibia, the writer, combining these principles with those of the Quengel method as outlined by Mommsen, has devised the following non-operative procedure, which is applicable in this type of case where operation might be contra-indicated or perhaps refused.

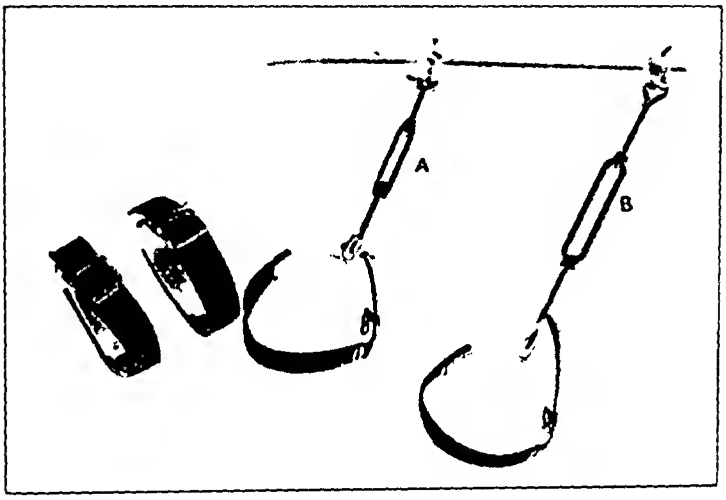

FIG. 1

Turnbuckle *A* controls posterior luxation; turnbuckle *B* corrects the flexion deformity. The direction of either force is controlled through the perforated bar.

A plaster-of-Paris spica is applied from the costal cage to the involved knee, preferably with a V-shaped tongue covering and protecting the patella. A separate plaster bandage is applied from below the knee to the toes with the foot at right angles. Padding must be well applied at the sites of maximum pressure,— the anterior surface of the lower thigh and the patella, the posterior surface of the upper portion of the leg, and behind the heel and the tendo achillis.

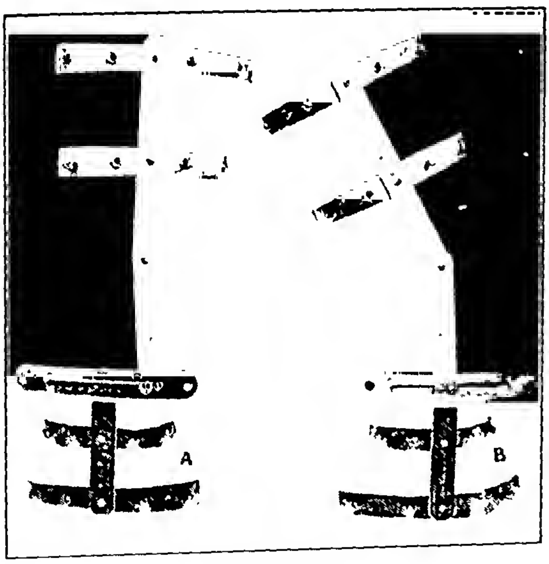

FIG. 2

Hinge with sliding device incorporated in the lower segment. Note position of the sliding bar prior to (hinge *A*) and during (hinge *B*) control of the posterior displacement of the upper portion of the tibia. The screws are tightened to maintain each correction.

A perforated bar is incorporated into the thigh portion of the plaster spica and turnbuckles *A* and *B*, of varying sizes, are attached to the leg. (See Figure 1.) When, by means of turn-

*Service of Harry Finkelstein, M.D.

Fig. 3

Showing the entire apparatus assembled. Turnbuckle *A* has been detached and the sliding hinge fixed to allow correction of the flexion deformity through turnbuckle *B*.

buckle *A*, the posterior displacement is completely corrected, as noted by control roentgenograms, the lateral hinges are incorporated with their axes in the line of the femoral epicondyles. Turnbuckle *A* is removed and correction of the flexion is carried out through turnbuckle *B* (Figs. 2 and 3).

The slot constructed at the lower end of the hinge allows repeated control of the recurring posterior luxation by reinserting turnbuckle *A*, without altering the position of the axis of the hinge.

This apparatus was of striking value in treating a six-year-old male child with a severe 90-degree flexion deformity of the right knee, the site of proved tuberculous infection. The debilitative condition and youth of the patient contra-indicated operative intervention. Numerous types of hinges, of elastic traction and turnbuckles, and of plaster-of-Paris bandages were employed, each resulting in a persistently recurrent and severe posterior displacement of the tibia. The method of treatment described was instituted with complete correction of both deformities in one month and with a minimum of discomfort to the patient. Careful clinical and laboratory observations failed to disclose any disturbance, either local or general, of the disease process.

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A FLEXIBLE NEEDLE ("FLEXO-NEEDLE")

Its Use in the Nicola Operation for Recurrent Dislocation of the Shoulder *

BY A. M. RECHTMAN, M.D., F.A.C.S., PHILADELPHIA, PENNSYLVANIA

From the Orthopaedic Service of the Jewish Hospital of Philadelphia

While the Nicola procedure is the most favored form of operation in the treatment of recurrent dislocation of the humeral head, much effort is required, involving considerable loss of time, in threading the tendon of the long head of the biceps through the drill hole (or canal) in the upper end of the humerus. Inasmuch as this is due to the lack of an efficient guiding instrument, a flexible needle, fitted with a heavy linen guide suture, has been devised, which has served to shorten the time and to improve the technique of this operation.

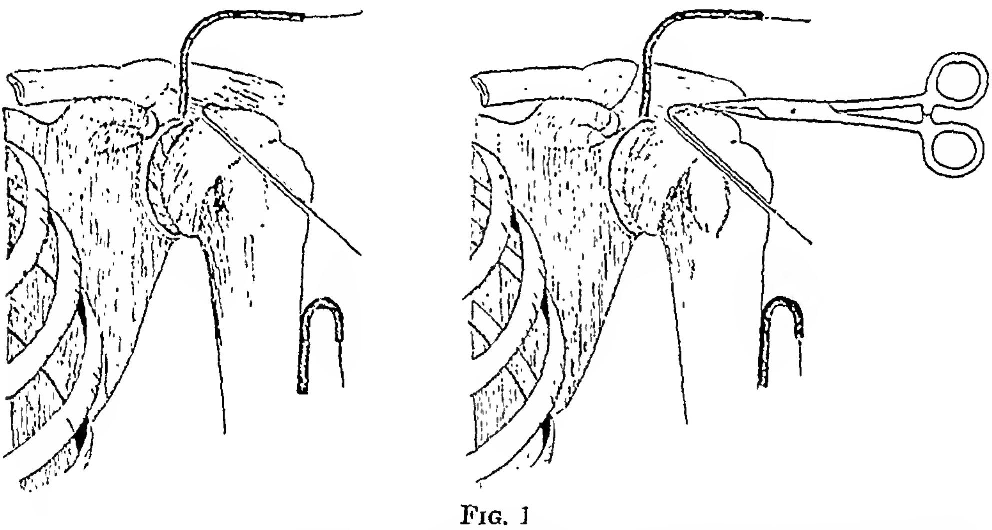

FIG. 1

Diagrammatic representation of the shoulder girdle, showing the cut biceps tendon, drilled canal in the upper end of the humerus, flexible needle in the canal, and the hemostat withdrawing the needle from the joint.

The patients who require this operation are frequently muscular, making the operative wounds deep. To facilitate threading the tendon in its new course from above downward through the drill hole, Nicola suggests stripping the clavicular origin of the deltoid muscle. However, with the aid of the flexible needle, this is not necessary.

With the use of this needle, in following the Nicola procedure, a shorter incision may be made. The muscles are separated, the tendon of the long head of the biceps is freed and divided, and a canal is drilled into the upper end of the humerus (as suggested by Nicola). The capsule is opened and a long suture is fastened to the cut end of the proximal portion

* Presented at the joint meeting of the Philadelphia Orthopaedic Club and the Orthopaedic Section of the New York Academy of Medicine, Philadelphia, Pennsylvania, November 20, 1936.

of the biceps tendon. The flexible needle, with its attached guide suture, is then passed from below upward through the drilled humeral canal. (See Figure 1.) The needle is grasped with a hemostat and, because of its flexibility, it can easily be drawn from the drilled canal and through the incision made in the capsule. Of course, the distal end of the suture is not drawn through the drill hole.

The flexo-needle is removed, and the guide suture is tied to the suture attached to the tendon and then pulled through the bony canal. Formerly this was often the most time-consuming part of the operation, whereas, with the flexible needle and the guide suture, all this may be accomplished in a few moments.

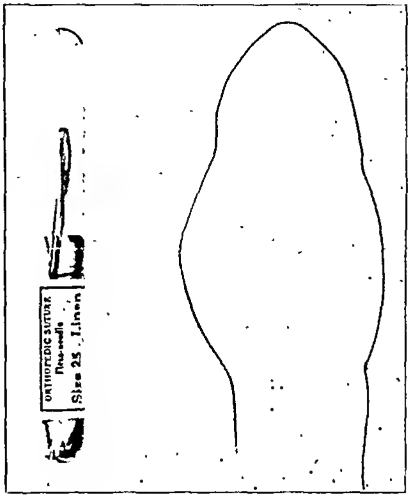

FIG. 2

Flexible needle with swedged-on linen thread. Needle sealed in tube. Shape of needle distorted to suggest its flexibility.

The flexo-needle is made of untempered steel which permits of any degree of flexibility. The needle is three inches long and has a diameter of twenty-six thousandths of an inch. (See Figure 2.) The needle is the swedged-on type and the guide suture is a black linen thread, twenty-eight inches in length and tested to twenty pounds of tension, so that it is about twice the strength of silk. The needle and thread are packed in individual glass tubes containing alcohol. The suture is sterile and it may be boiled.

The needle, although flexible, has sufficient rigidity, when straight, for firm handling and use. The needle may be cut to any required length and bent into any desired shape to facilitate its passage through and around bones. The end of the needle is sharp, so that it may be used to suture tendons and other soft tissues. It was devised, however, to carry a heavy guide suture. When the end of the needle is grasped with a hemostat as it emerges from a drill hole in a bone, the needle is sufficiently flexible to bend readily about the bone and it may be removed with practically no added injury to the bone or to its cartilaginous covering.

In addition to its use in the Nicola operation, the flexible needle has also proved a valuable aid in facilitating other operative procedures. With its assistance, a Gigli saw may be passed around a bone with comparative ease, tendons may be more easily passed through drill holes in bones and tendons, and fascia and muscles may be anchored deeply into cavities at the base of trap doors made in bones. The needle and its attached guide suture facilitate the placing of fixative kangaroo or wire sutures through and around bones.

NICOLA, TOUFICK: Recurrent Anterior Dislocation of the Shoulder. A New Operation. J. Bone and Joint Surg., XI, 128, Jan. 1929.

WIRE FIXATION OF THE SMITH-PETERSEN NAIL

BY VERNON L. HART, M.D., MINNEAPOLIS, MINNESOTA

Several surgeons who have had considerable experience with the Smith-Petersen three-flanged nail for the internal fixation of fractures of the neck of the femur have reported that there is a tendency for the nail to slip out of the femur.

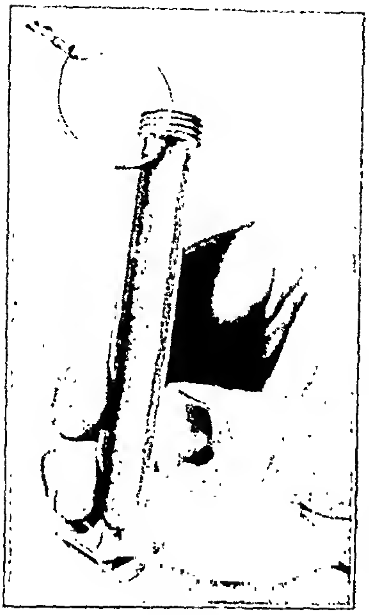

FIG. 1

Smith-Petersen nail with stainless-steel wire passed through the cannulated head. The wire ends are twisted and firmly fixed after the wire is threaded through a hole drilled through the cortex of the femur. (See Figs. 2 and 3.)

Dr. Melvin S. Henderson[2] of the Mayo Clinic recently reported the lag-screw method of internal fixation. Dr. Henderson stated: "The method was developed because in some instances the metal flanged nail became loose."

R. Watson Jones[1] of Liverpool has reported his experience: "It might be thought probable that absorption of bone round the nail due to an irritative hyperaemic decalcification would account for frequent failure. . . . That there is some decalcification is undoubted, and the remarkable tightness of the nail when it is first driven in is not maintained for more than a few weeks. After that time it is not difficult to slide the nail up and down its socket in the bone." He described the use of a stainless-steel domed cap which is screwed over the head of any nail which shows a tendency to slip out of the bone.

The writer wishes to present a simple modification of the Smith-Petersen nail which is used routinely to prevent the nail from gradually slipping and losing its relationship with the proximal or head fragment. (See Figures 1, 2, and 3.) A centrally cannulated Smith-Petersen nail, which has a relatively small oblique hole drilled into the cannulated head, is used. Following successful introduction of the nail, a piece of stainless-steel wire is passed through the cannulated head. The ends of the wire are twisted and firmly fixed after the wire is passed through a small hole drilled through the cortex of the distal fragment or shaft of the femur.

The nail should be introduced with the hole facing the greater trochanter, since the segment of the head of the nail facing the greater trochanter is not buried as deeply within the cortex of the femur after the head is driven home. (See Figure 2.)

1. JONES, R. WATSON: Fractures of the Neck of the Femur. British J. Surg., XXIII, 787, 1936.
2. SIMPSON, W. C., AND HENDERSON, M. S.: Lag Screw Fixation in Ununited Fracture of Neck of Femur. Proc. Staff Meeting Mayo Clinic, XI, 573, 1936.

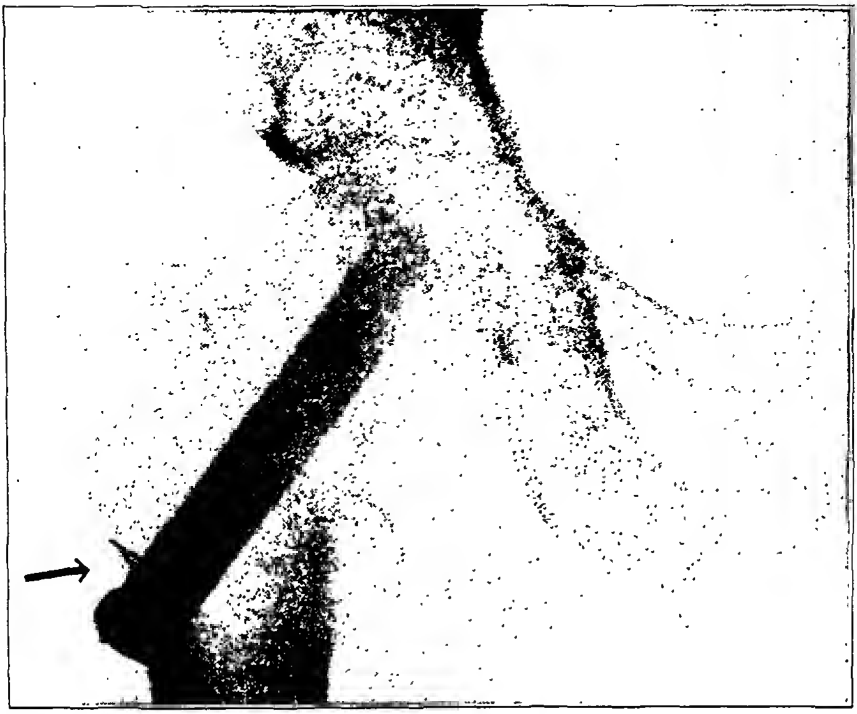

Fig. 2

Arrow points to stainless-steel wire fixation of Smith-Petersen nail.

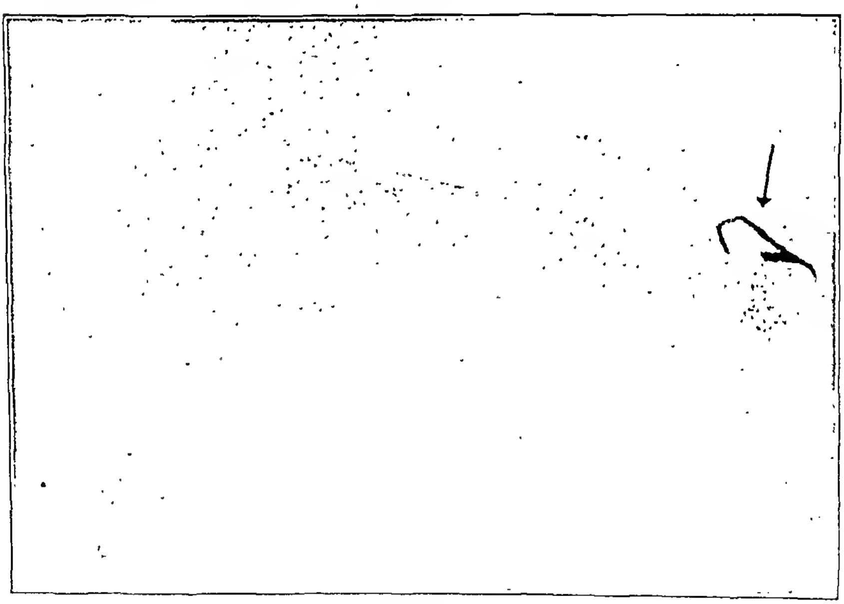

Fig. 3

Lateral view of femoral neck and Smith-Petersen nail. Arrow points to the wire fixation of the nail.

LEG HOLDER FOR OPERATIONS ON THE KNEE AND ON THE FEMUR *

BY EDGAR D. OPPENHEIMER, M.D., NEW YORK, N. Y.

In operations on the knee, the tibia is pulled away from the femur in order to separate the joint surfaces. A large object over which the flexed knee can be laid is desirable, but it must be adjustable and it must be handled so as to maintain the operative sterility. Also, in operating on the shaft of the femur, as in the case of a fracture, the tensor fasciae latae and the hamstrings must be relaxed in order to have traction on the lower fragment. It is also desirable to elevate the thigh for a more lateral exposure. In working with the knee flexed, it is easier to retract the muscles, to reduce the fragments, and to maintain effective traction. Here again, an adjustable sterile platform is needed. To meet these requirements, the author has devised a leg holder, a description of which follows.

This apparatus is made of rustless steel, weighs five pounds, and, when folded, is twenty-two inches over-all. It can be sterilized with the basins or the instruments. It consists of a platform, eight inches long, which goes under the thigh and is hinged to a ten-inch support for the leg. From each of these supports project two jointed legs which are connected by a plate, two inches square, making a parallelogram. Since the supporting rods are held at the pivotal point on a two-inch plate, the pivot is not on one point. If these rods are crossed, and if the plate is inverted, the apparatus is five inches lower and can be used for a small limb and the pivotal point remains as before. A transverse longitudinal bar with a ratchet allows locking at any degree of angulation. The operator can adjust it and remain sterile. If the apparatus is locked at 90 degrees, making a square, the foot is free from the table, and the weight of the assistant's hand upon the foot pulls the knee down and forward and pivots it over a fulcrum below. The leg is supported by the shelf and the thigh hangs down from it. Thus traction is applied on the lower femoral fragment, and the fracture is readily reduced.

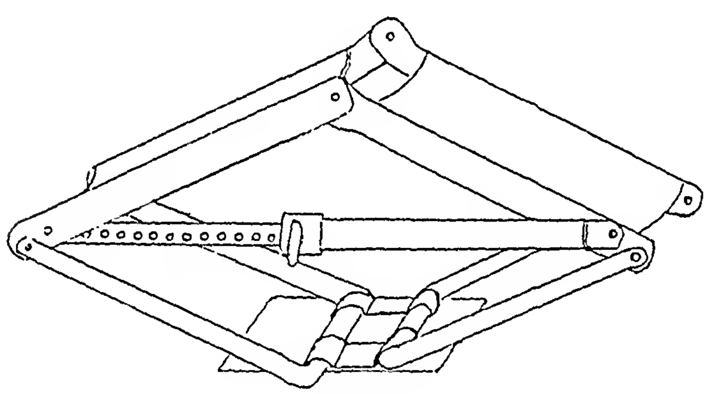

Fig. 1

The practical value of this apparatus lies in the facts that it is sterile

* The apparatus described in the two papers by Dr. Oppenheimer was exhibited at the Annual Meeting of the American Academy of Orthopaedic Surgeons, Cleveland, Ohio, January 1937.

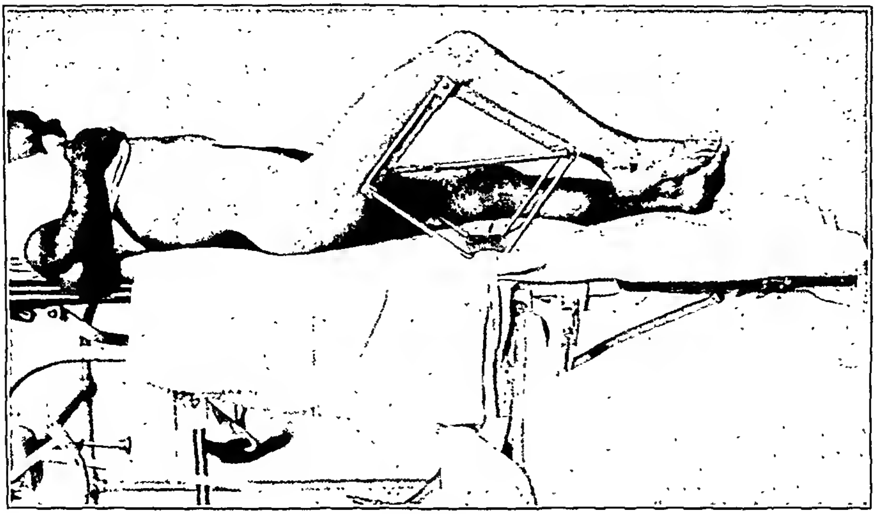

Fig. 2

and that it can be adjusted by the surgeon. An assistant would be unable to hold the limb effectively. Therefore, this leg holder simplifies the two operative manoeuvers considerably.

FRAME FOR APPLICATION OF PLASTER JACKET IN PRONE POSITION

BY EDGAR D. OPPENHEIMER, M.D., NEW YORK, N. Y.

Plaster jackets are applied with the patient either in a hanging position or in a horizontal prone position. Most of the jackets are put on for spinal injuries, lumbago, sciatic scoliosis, and conditions which make it impossible to handle a patient in the hanging position as comfortably as when he is recumbent and relaxed. Many simple frames with a stretched canvas have been improvised for this purpose. Usually hyperextension is desired, and some of the fracture tables provide for this. The author believes that the apparatus which he has devised will be helpful in that it accomplishes hyperextension, makes the work easier, and is simple and inexpensive to construct.

This apparatus has the appearance of a sled on which the patient rests face down with the knees fully flexed, as do children on their sleds. The over-all length is thirty-eight inches and the width is twenty inches. The height of the frame, when folded, is six inches. The apparatus is made of gas pipe, three-quarters of an inch in diameter; it weighs eight pounds and is portable. The end bars are raised about five inches above

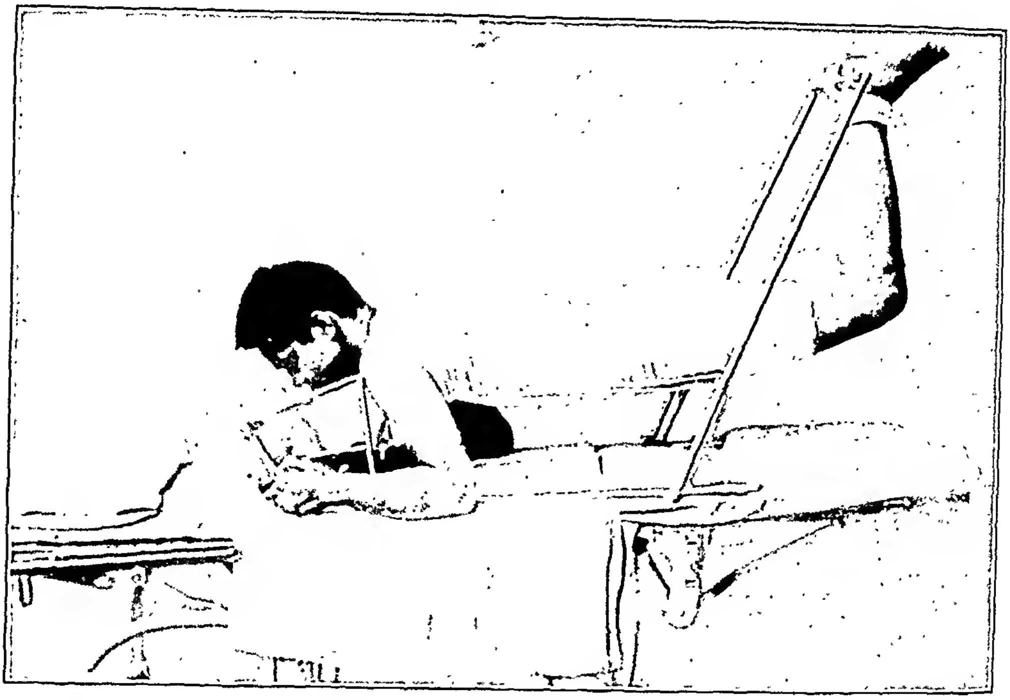

FIG. 3

the runners or side bars. There is a movable cross-bar which should rest just below the chin. Ordinary muslin, about seven inches wide, is stretched between the two end bars, and is fastened and wound on a spool or tube held by a ratchet. Tightening the ratchet prevents sagging and limits extension. The movable cross-bar at the neck is raised above the ends and, instead of being straight, is bent downward in the middle. In this way the sides of the canvas or the muslin are tighter than the middle part, which prevents flattening of the abdomen. A short longitudinal slit is cut in the muslin through which the patient puts his nose, enabling him to rest his head without forced hyperextension of the neck.

The lower bar should cross the thighs three or four inches below the anterior superior spines and the movable cross-bar is adjusted above the sternum after the patient has been placed in position. There is a second jointed hoop, about thirty-six inches long and hinged at the lower end, which can be folded flat when not in use. After the patient has been placed prone on the sled this hoop is elevated and the feet are fastened to it by a double sling around the ankles. The height to which the feet are raised controls the hyperextension, relieves the pressure of the lower bar against the thighs, and prevents the patient from rolling off sidewise. If the legs are drawn to one side, lateral bending is obtained. After the jacket has been applied, the foot holder is dropped, the patient is rolled over on his back, and the muslin is cut off.

This frame differs from others in that: (1) the lateral bars are depressed to be out of the way in plaster application; (2) the sling is looser in the middle than on the sides; (3) it is adjustable as to size; (4) it is adjustable as to the amount of extension; (5) it has a practical leg holder; and (6) it is portable.

MULTIPLE SESAMOIDS OF THE HANDS AND THE FEET

BY ROBERT F. PATTERSON, M.D., F.A.C.S., KNOXVILLE, TENNESSEE

In the upper extremity, sesamoid bones are found only on the palmar surface of the hand. According to Gray, two are constantly present at the metacarpophalangeal joint of the thumb; one is frequently present at the corresponding joint of the little finger, and one or two at the same joint of the index finger.

In the lower extremity, two sesamoid bones are normally present at the metatarsophalangeal joint of the great toe. Occasionally one or two are found under other toes at the corresponding joint. Dwight states that one may be found under the interphalangeal joint of the great toe in 50.6 per cent. of the cases, one at the metatarsophalangeal joint of the second toe in 1.8 per cent. of the cases, and two at the same joint of the little toe,—at the tibial side in 5.5 per cent. of the cases, and at the fibular side in 6.2 per cent. of the cases. There is a distal interphalangeal sesamoid opposite the middle of the joint of the second toe in 8 per cent. of the cases. The author can find no mention of a case in which these bones occurred in all of the toes of both feet as well as at unusual sites in the hands.

The following case is presented as an anatomical curiosity. The complete uniformity with which the bones occurred in the corresponding extremities is noteworthy.

Mrs. H. B. T., a housewife, presented herself for treatment of an old sprain of her ankle with residual tenderness in the ankle and injury to the ball of the right foot. Roentgenograms of the feet revealed the presence of multiple and uniform sesamoids. One

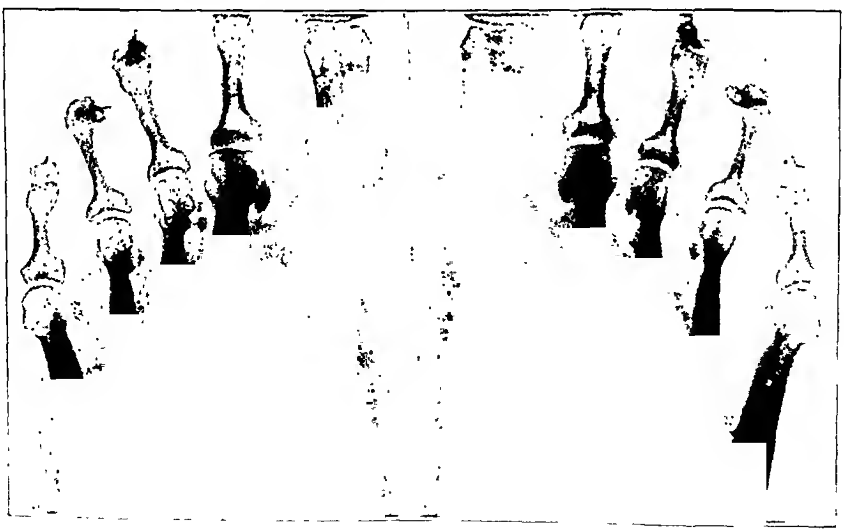

FIG. 1

Roentgenogram of the feet, showing the presence of sesamoids beneath all the toes. At the left third toe there are either two bones or an ununited fracture of the sesamoid.

or more was present at every metatarsophalangeal joint of both feet, as shown by Figure 1. Roentgenograms of the hands showed the presence of double sesamoids at the metacarpophalangeal joints of both thumbs and little fingers, also a single one at the corresponding joint of each index finger.

NOTE: The author wishes to express appreciation to Dr. Glenn Grubb, of Norris, Tennessee, for roentgenograms of this case.

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EWING'S SARCOMA

An Atypical Case with Necropsy Findings

BY HERMAN CHARACHE, M.D., BROOKLYN, NEW YORK

*From the Brooklyn Cancer Institute**

Definitely proved cases of Ewing's sarcoma are relatively uncommon, and those with positive necropsy findings are few in number; therefore, the author feels that the following case will be of interest.

F. B., a white female, eight years of age, was admitted to the Brooklyn Cancer Institute on August 1, 1932, complaining of a swelling of the right side of the face and scalp, weakness, and loss of weight.

In November 1931 pain and swelling in the left knee, not associated with any trauma, had developed. In another hospital a diagnosis of Ewing's tumor had been made and roentgenotherapy had been administered. The pain and swelling had disappeared, and the patient was believed to be cured.

Three months later a small nodule appeared on the head, followed very shortly by a larger swelling in the right parotid region. The patient was then admitted to the Brooklyn Cancer Institute for treatment.

When four years of age she had had some tuberculous glands removed from the neck. Her family history was irrelevant.

On admission, she weighed forty-three and three-fourths pounds; her temperature was 99; the pulse, 90; and respiration, 20.

At the vertex of the scalp was a firm nodule, three by three centimeters, firmly attached to the underlying structures. There was a similar tumor, six by six centimeters, in the right parotid region at the ramus of the mandible.

Chest examination revealed a slight bulging of the right chest posteriorly, close to the base of the scapula. Two areas of dullness and loss of breath sounds were found at both bases posteriorly.

Abdominal examination showed liver enlargement of about two fingerbreadths below the costal margin; the spleen was not palpable, nor were any other masses felt.

Examination of the extremities revealed that the upper fifth of the left tibia was larger than that of the right. There was no evidence of any swelling of the soft tissues.

The urine was not pathological; Bence-Jones protein was absent. Blood examination revealed a marked secondary anaemia and a negative Wassermann.

Roentgenographic examination showed destructive changes with considerable lime-salt absorption and loss of normal structure of bone detail in the upper two inches of the diaphysis of both tibiae and in the lower end of the diaphysis of the right femur just above the epiphyseal line. The skull did not show any pathological change. The same destructive changes were seen in the right mandible. Roentgenograms of the chest revealed a large tumor mass in the mediastinum, partially infiltrating the bases of both lungs.

During the time the patient remained in the hospital, multiple nodules appeared on the scalp, firm and hard at first, later becoming soft and cystic and breaking down, discharging material resembling coffee grounds. A septic temperature, ranging from 99 to 103, developed with a corresponding change in pulse. The patient lost weight very rapidly and died on December 10, 1932.

*Ira I. Kaplan, M.D., Director, Division of Cancer, Department of Hospitals, New York City.

Fig. 1

External surface of calvarium, showing multiple tumors.

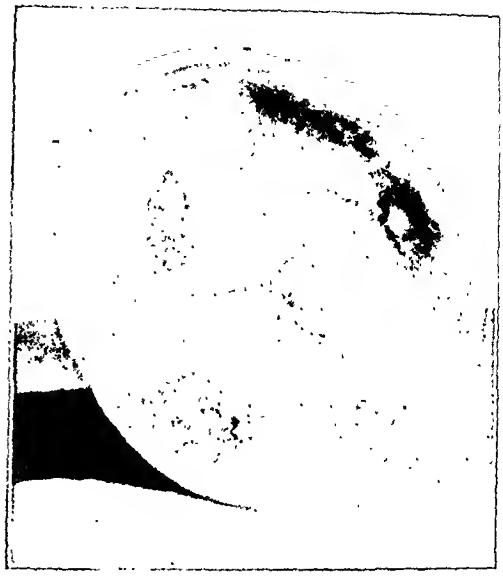

Fig. 2

Internal surface of calvarium, showing penetration of tumors through both tables of skull.

Post-Mortem Examination

The body was shrunken and emaciated, and presented a number of tumefactions in the cranium, in the angle of the jaw, and in the left knee. There were six such tumefactions in the skull, the largest being over the parietal and occipital regions and measuring about four centimeters in diameter. These tumors were not adherent to the scalp, but eroded through the calvarium, forming depressions in the brain with invagination of the dura into the brain substance. A small nodule, measuring two and five-tenths centimeters in diameter, perforated the dura at its attachment near the crista galli, and its pressure tore away the dura from its bony attachment. This nodule made its way into the left inferior frontal gyrus.

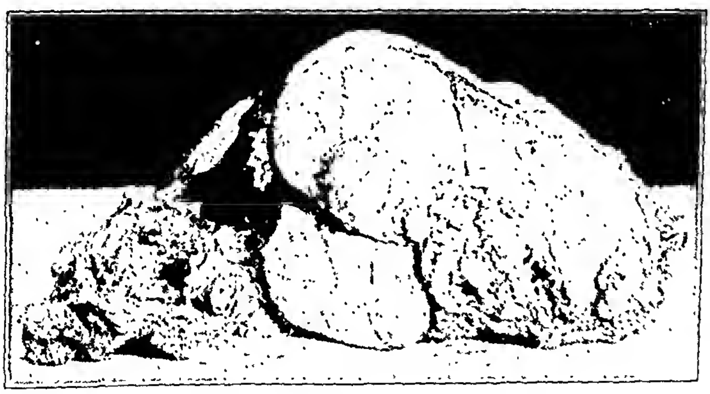

Fig. 3

Post-mortem specimen, showing metastatic tumors at the bases of both lungs.

The lungs were compressed and pushed upward by two large grapefruit-like masses which originated in the middle mediastinum and encroached on both lungs, the pericardium, and the pleura. The tumors were soft and somewhat cystic, partially degenerated and liquefied in the center. The surrounding area had the consistency of brain tissue. The tumor in the mandibular region had the same consistency. The periosteum of the left tibia was markedly thickened. The bone marrow had a milk-like consistency. The rest of the organs did not show any gross evidence of malignancy.

The diagnosis of Ewing's sarcoma was confirmed by histological examination of the tumor by Dr. Charles F. Geschickter.

This case is of particular interest as it falls in the atypical group

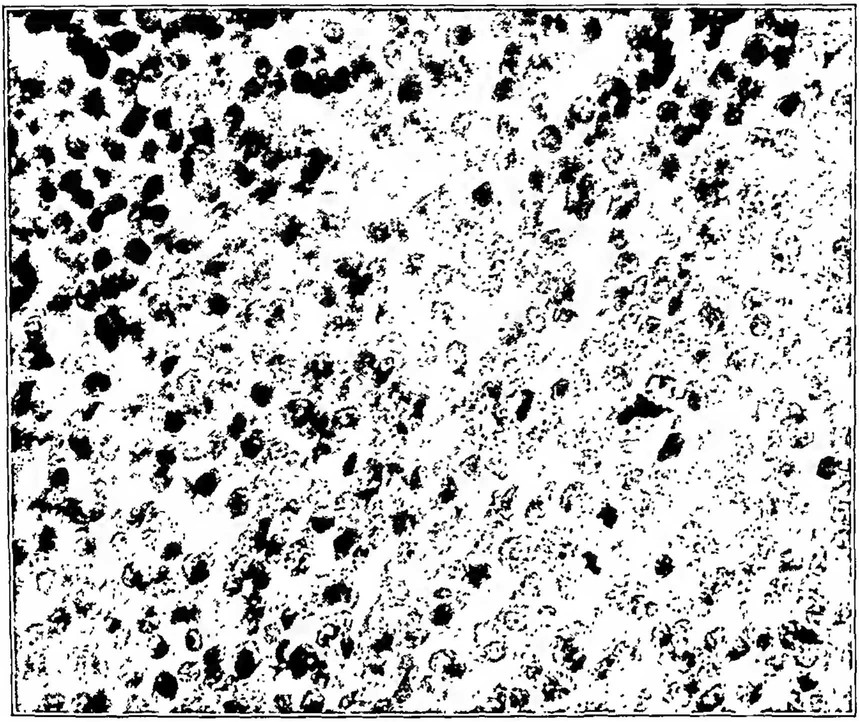

FIG. 4
Photomicrograph, showing lymphoid nature of Ewing's sarcoma.

of Ewing's sarcoma. The tumor invaded the epiphyseal end of the tibia instead of the shaft of the bone, affecting largely the bone-marrow cavity without any marked periosteal changes, as seen in the usual "onion-peel" variety The skull metastasis in this case is of interest. Geschickter found only one similar case in his series.

Histologically this tumor would tend to prove Geschickter's opinion that Ewing's sarcoma is of lymphatic origin.

NOTE: The author is indebted to Dr. Geschickter for his aid in studying the case and for the photomicrographs which he kindly sent from the Johns Hopkins Hospital.

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A SANITARY FRAME FOR CARE OF CHILDREN IN CASTS

BY DAVID M. BOSWORTH, M.D., NEW YORK, N. Y.

Four years ago, Dr. A. S. Price built the first frame like that shown below for support of his little daughter while she was in plaster following an operation. Its efficiency in making the child comfortable and in keeping her clean and dry was so marked that the support is now used for children in spica casts on the Orthopaedic Services in six hospitals in greater New York. The nursing staffs are universally enthusiastic about it, and it has proved so satisfactory that we felt its publication would be helpful to others; for this reason, the writer is including a diagram with dimensions as well as photographs of its use.

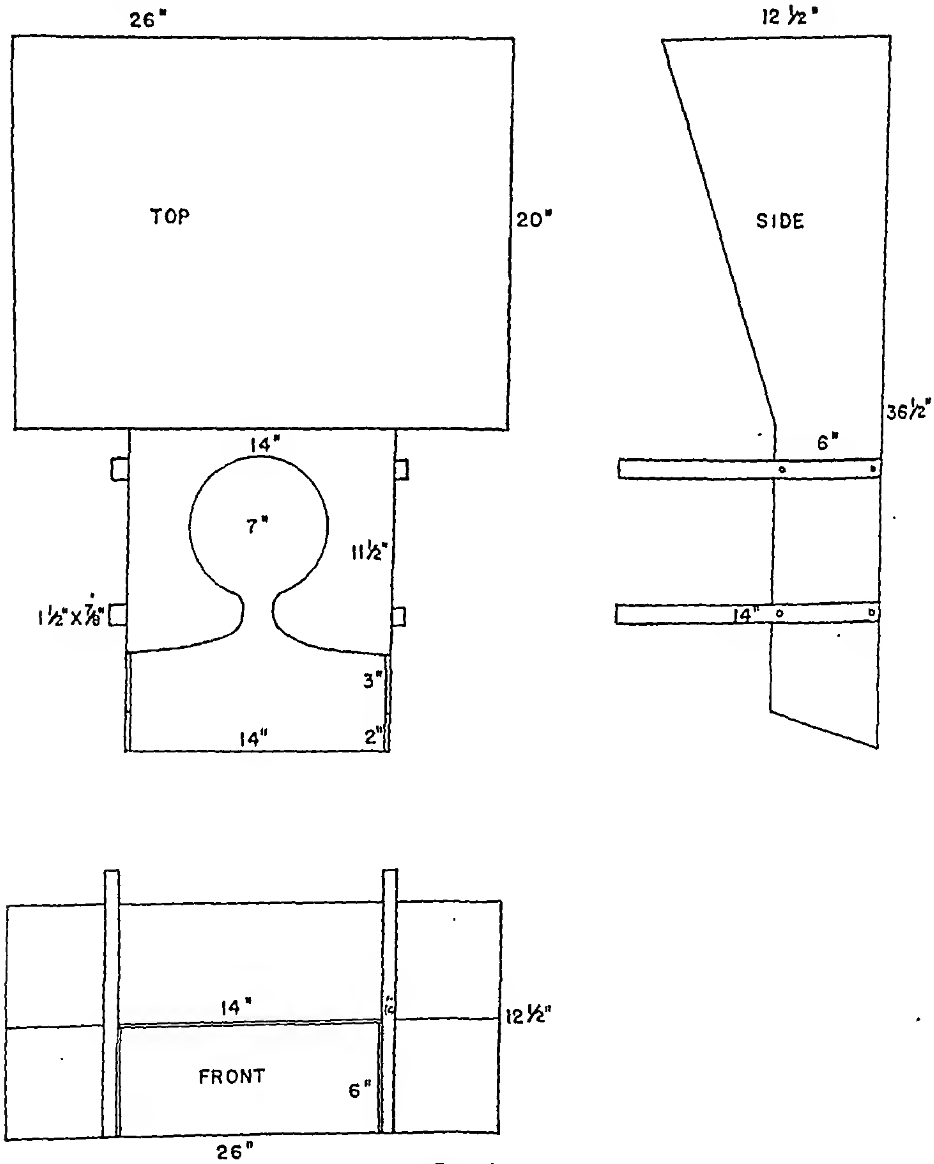

Fig. 1

Plan and dimensions of wooden frame.

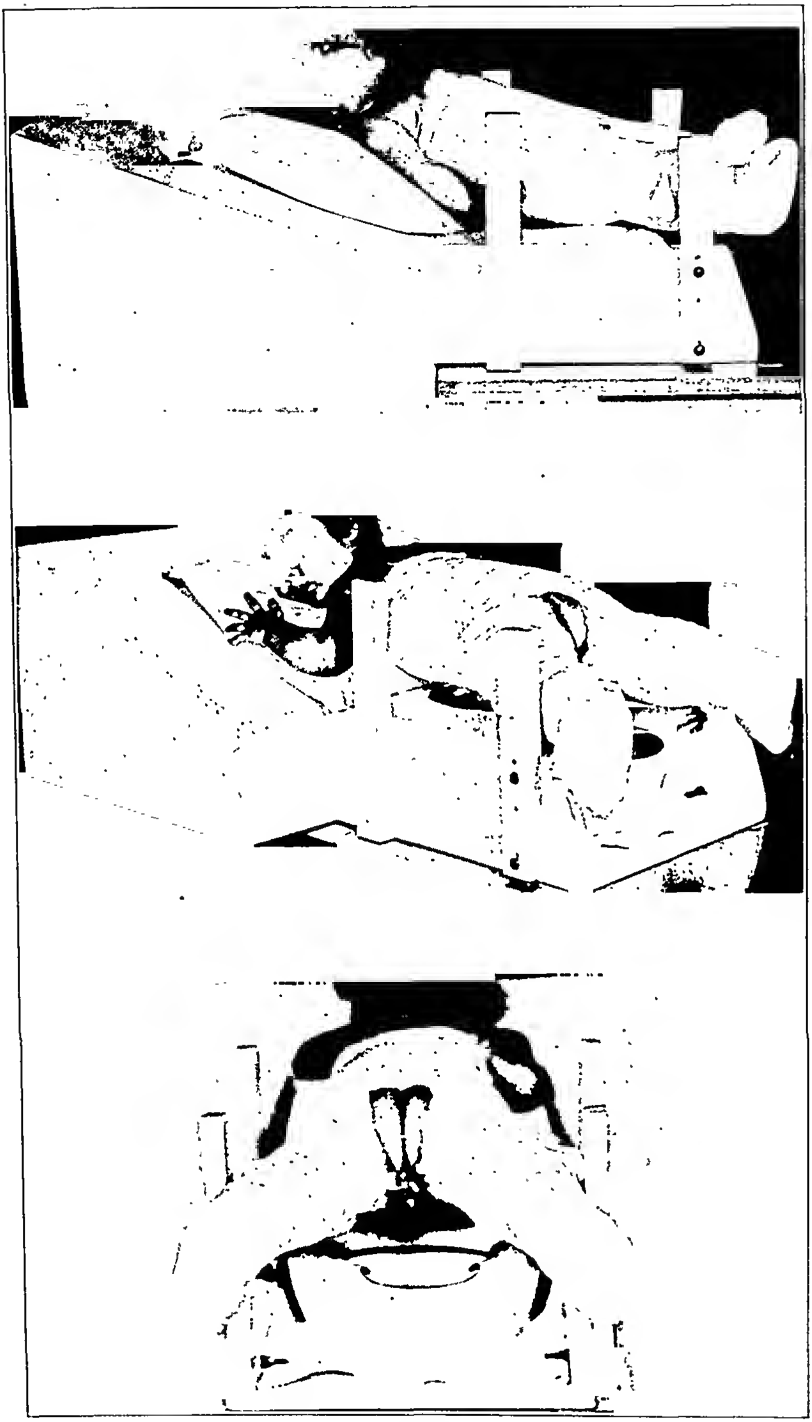

FIG. 2

Child placed on frame on her face and on her back. Note the impossibility of the child's soiling the cast or the dressing under the cast. The lower pegs are fitted with winged nuts on the bolts to provide for placing them inside the frame if a narrower position is desired.

In a case in which the child is very young and one extremity is in plaster, the other extremity is also included during the period of actual treatment, so as to allow for use of the frame. The feet should be included, so that the child does not slide down into the cast. Previous to this, there has been some trouble due to irritation of the upper inner thighs at the plaster margins. With the use of the frame and the double hip spica, fewer complications and infections have resulted from operations about the pelvis, since it is impossible for the child to soil the post-operative dressing. It is likewise impossible for the child to get out of the frame, and the amount of nursing attention necessary to prevent him from falling out of bed is markedly reduced.

SPRENGEL'S DEFORMITY

Report of a Case of Bilateral Involvement

BY S. K. LIVINGSTON, M.D., F.A.C.S., HINES, ILLINOIS

Bilateral failure of the scapula to descend is rather unusual. Bergel found the unilateral deformity in approximately one out of every 3,000 military recruits between the ages of twenty and twenty-two; the deformity occurred more often on the left than on the right. The following case is of interest because of the bilateral involvement.

W. E. M., aged forty years, a farmer, was admitted for diagnosis of an increasing weakness in the arms.

Examination showed an exceedingly well-developed and well-nourished male. The neck was short and powerful, and the head moved on the torso through a normal range. The trapezius, the deltoid, the biceps, and the triceps were especially powerful. The sternum was markedly depressed. The arms could not be raised above the horizontal position, and this position could only be maintained for a short time because of weakness and pain in the scapulae. The scapulae were rotated in such a manner that the vertebral borders, instead of being parallel to the spinal column, were lying closer to the axillae, and the inferior angle nearer the vertebrae. The subscapular angles were more acute than normal. The transverse diameter of the scapulae was greater than the vertical. There were no bony,

Fig. 1
Showing prominence and malposition of the freely moving scapulae and acute subscapular angles.

Fig. 2
Showing marked depression of the sternum.

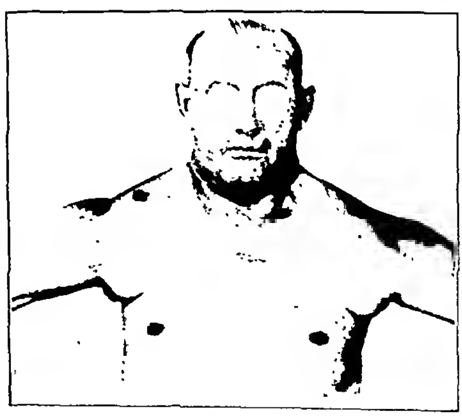

Fig. 3
Compensatory hypertrophy of the musculature of the neck, the shoulders, the back, and the arms. The arms could not be abducted beyond the horizontal position.

cartilaginous, or fibrous connections of the scapulae with the vertebrae; the scapulae moved freely in all planes upon motion of the arms. There did not appear to be any defects of the musculature, ribs, or vertebrae. The powerful muscular development was apparently compensatory for the weakness resulting from the scapular detachment. The Klippel-Feil syndrome did not exist.

REFERENCE

BERGEL, DAGOBERT: Zwei Fälle von angeborenem Schulterblatthochstand. Ztschr. f. orthop. Chir., XXVI, 148, 1910.

FREDERICK JULIUS GAENSLEN

1877–1937

On March 11, 1937, Frederick Julius Gaenslen died at his home at the age of fifty-nine. In the early afternoon of his life this skilled workman was forced to lay down his tools.

Dr. Gaenslen was born in Milwaukee of German parents who came from Germany in 1870. His training was essentially American, for he obtained his preliminary education in the public schools of Milwaukee. He graduated from the University of Wisconsin in 1899 and received his medical training in Johns Hopkins Hospital, from which institution he took his degree in 1903. After an internship in a New York hospital, he established himself in general medical practice in Milwaukee, which he followed until 1912.

His unusual initiative and ability soon gave him the urge toward a larger field of achievement. He turned to orthopaedic surgery and began his career by studying in Europe. From that time he confined his work to the practice of this branch of surgery. He played an active part in the development of orthopaedic surgery in his section of the country and contributed so largely to the advancement of this specialty that he was considered the Father of Orthopaedic Surgery in Wisconsin and was an outstanding figure in the Middle West. He was a charter member and a past president of the Clinical Ortho-

paedic Society and a member of the American Orthopaedic Association, of which he was President in 1936.

Early travel gave to this earnest student a breadth of vision that helped to develop an excellent judgment and in later years supplied him with whimsical anecdotes and reminiscences. Eager participation in the work of scientific organizations benefited them as well as himself. His discussions from the floor were a delight to the audience. Accurate clinical observation, detailed records, and laboratory experimentation furnished the material from which he drew to enrich the orthopaedic literature. The splendid results of his surgery are monuments to his meticulous technique and attention to detail.

The memory of the man will long endure in the hearts of those who loved him for his human qualities. Through formal lecture and by precept, he instilled in his students the highest ideals of professional attainment. By his untiring energy, consummate skill, and absolute integrity he engendered a respect for orthopaedic surgery which remains as a heritage for those who followed him. His achievement in orthopaedic surgery needs no word of elaboration. The regard of his colleagues is attested by their grief at his passing.

News Notes

The Fifty-First Annual Meeting of the American Orthopaedic Association will be held in Lincoln and Omaha, Nebraska, on June 2, 3, and 4, 1937, under the presidency of Dr. H. Winnett Orr. Headquarters will be at the Cornhusker Hotel. Among the foreign guests expected are: Mr. R. Watson Jones, of Liverpool; Prof. Lelio Zeno, of Rosario; Prof. Charles Lasserre, of Bordeaux; and Prof. Juan Farill, of Mexico City. Since this meeting commemorates the Fiftieth Anniversary of the American Orthopaedic Association, a program of special interest has been arranged. The following papers are to be presented:

WEDNESDAY, JUNE 2

Morning Session

Subastragalar Arthrodesis. A New Version of an Old Subject.
Dr. R. Plato Schwartz, Rochester, New York.

Acute Osteomyelitis of the Long Bones in Adults.
Dr. Isadore Zadek, New York City.

Acute Osteomyelitis—Treatment in the Light of Recent Serological Findings.
Dr. D. E. Robertson, Toronto, Canada.

Treatment of Early Slipping of the Femoral Epiphysis.
Dr. Leo Mayer, New York City.

Afternoon Session

Closed Reduction of Fractures of the Neck of the Femur.
Dr. Guy W. Leadbetter, Washington, D. C.

Internal Fixation of Fresh Fractures of the Neck of the Femur.
Dr. M. N. Smith-Petersen, Boston, Massachusetts.

Comments on Internal Fixation of Fresh Fractures of the Neck of the Femur.
Dr. W. W. Plummer, Buffalo, New York.

Reconstruction Operations for Ununited Fractures of the Neck of the Femur.
Dr. E. G. Brackett, Boston, Massachusetts.

THURSDAY, JUNE 3

Morning Session

Synovectomy: Its History to Date.
Dr. Paul Swett, Hartford, Connecticut.

Presidential Address. The Contribution of Orthopaedic Surgery to the Lister Antiseptic Method.
Dr. H. Winnett Orr, Lincoln, Nebraska.

The Development of Fracture Treatment in Great Britain.
Mr. R. Watson Jones, Liverpool, England. (By invitation.)

Experiences with Massive Bone Grafts.
Dr. Dallas B. Phemister, Chicago, Illinois.

Afternoon Session

Dashboard Dislocations of the Hip.
Dr. Robert Funsten, University, Virginia.

History of Orthopaedic Surgery and the American Orthopaedic Association.
Dr. Robert B. Osgood, Boston, Massachusetts.

Federal and State Care of Crippled Children.
Dr. R. C. Hood, Washington, D. C. (By invitation.)

Studies of the Longitudinal Growth of Bone.
Dr. Edward L. Compere, Chicago, Illinois.

On Friday, June 4, the members and guests will leave by special train for Omaha, where a clinical program will be presented at the University Hospital under the direction of Dr. J. P. Lord, Dr. Robert D. Schrock, and their associates.

The first Executive Session will be held on Wednesday, June 2, at 12:00 noon and the second Executive Session will take place on Friday, June 4, at 12:00 noon in Omaha.

On Wednesday evening a studio supper has been arranged for members and guests in Morrill Hall, University of Nebraska, followed by a lecture in the University Museum on "Some Interesting Palaeological Findings in Nebraska" by Prof. E. H. Barbour, Director of the Museum.

At 12:00 noon on Thursday, June 3, there will be a luncheon for the members and guests at the Nebraska State Capitol at which the Guest of Honor will be the Hon. Roy L. Cochran, Governor of Nebraska. The Annual Dinner will be held on Thursday evening at 7:00 o'clock at the University Club.

The Spring Meeting of the **British Orthopaedic Association** is to be held in Copenhagen and Stockholm on May 17 through May 21, 1937.

Many readers of *The Journal* occasionally find among their patients those who are handicapped by deafness. Perhaps all are not familiar with the valuable work which is being done by The Volta Bureau in helping such people to meet their special problems. The Volta Bureau was established by Alexander Graham Bell with money which he received as a prize for inventing the telephone. It was his wish that anyone confronting the problems of deafness might be assured of help. The services of The Volta Bureau are free. Pamphlets dealing with all phases of deafness, except medical problems, are available to all who ask for them. The address of The Volta Bureau is 1537 35th St., N. W., Washington, D. C.

At the last examination of **The American Board of Orthopaedic Surgery**, held in Cleveland on January 9, 1937, ninety-four candidates were certified. The personnel of the Board is as follows:

Dr. Willis C. Campbell, *President*	Representing the American Medical Association
Dr. Edwin W. Ryerson, *Vice-President*	Representing the American Academy of Orthopaedic Surgeons
Dr. Fremont A. Chandler, *Secretary-Treasurer*	Representing the American Medical Association
Dr. George E. Bennett	Representing the American Orthopaedic Association
Dr. Melvin S. Henderson	Representing the American Orthopaedic Association
Dr. Samuel Kleinberg	Representing the American Academy of Orthopaedic Surgeons
Dr. Philip Lewin	Representing the American Academy of Orthopaedic Surgeons
Dr. John C. Wilson	Representing the American Medical Association
Dr. Philip D. Wilson	Representing the American Orthopaedic Association

The next examination of the Board will be held in conjunction with the meeting of the American Medical Association at Atlantic City. Tentative plans call for the examination to be held on June 8. Applications should be in the Secretary's hands at least sixty days before the date of the next examination.

The certificate of this Board has become a prerequisite for membership in the American Academy of Orthopaedic Surgeons. The members of the American Orthopaedic Association, who have been exempted from examination heretofore, will be required to take the examination after July 1, 1937.

FREMONT A. CHANDLER, M.D., *Secretary*

The Fifth Annual Convention of **The American Academy of Orthopaedic Surgeons** was held in Cleveland, Ohio, on January 10, 11, 12, 13, and 14, 1937, under the presidency of Dr. Melvin S. Henderson. The attendance at this meeting was 787.

An exceptionally interesting program was presented, the details of which were published in the January issue of *The Journal.* Of especial interest were the seminars on the following subjects: "Shoulder Lesions", conducted by Dr. E. A. Codman, Boston; "Osteomyelitis", led by Dr. H. Winnett Orr, Lincoln; "Fractures of the Ankle", under the chairmanship of Dr. Philip D. Wilson, New York; and "Low-Back Lesions", led by Dr. Joel E. Goldthwait, Boston.

Five radio broadcasts were given in connection with the meeting as follows:

The Accomplishments of Orthopaedic Surgery.
Dr. Melvin S. Henderson, Rochester, Minnesota.

Physically Handicapped Children and Adults.
Dr. Edwin W. Ryerson, Chicago, Illinois.

Infantile Paralysis.
Dr. Albert H. Freiberg, Cincinnati, Ohio.

Recent Advances in the Causes and Treatment of Arthritis.
Dr. Robert B. Osgood, Boston, Massachusetts.

The Fracture Situation.
Dr. Willis C. Campbell, Memphis, Tennessee.

There were fifty scientific exhibits. The Gold Medal was won by Dr. R. Plato Schwartz and his associates, of Rochester, New York, for their exhibit on "Pathology of Gastrocnemius and Soleus Muscles and Tendo Achillis". The Silver Medal was presented to Dr. Weston A. Price, of Cleveland, Ohio, for his exhibit on "Field Studies among Primitive Races with Reference to Bone Development and Dental Caries". The Bronze Medal was given to Dr. Edgar Oppenheimer, of New York City, for his exhibit on "Apparatus for Fracture Management".

Certificates of Merit were awarded to the following men for the excellency of their scientific exhibits:

Dr. Willis C. Campbell Clinic, Memphis, Tennessee:	Endothelial Myeloma (Ewing Tumor). Ununited Fractures—Onlay Bone Graft.
Dr. Michael S. Burman, New York City:	Curare in Spastic Paralysis. The Spastic Hand. Certain Other Kinesiological Disturbances of the Hand.
Dr. Henry Milch and Dr. Maurice M. Pomeranz, New York City:	Upper Femoral Epiphysiolysis.
Dr. Earl D. McBride, Oklahoma City, Oklahoma:	Scoliosis. A New Derotation Apparatus and New X-Ray Method of Recording.
Dr. Keene O. Haldeman, San Francisco, California:	The Healing of Bone Following Injury and Infection.
Dr. James A. Dickson, Cleveland, Ohio:	Torticollis. Experimental and Clinical Studies.

The exhibits of the following were considered worthy of special mention: Dr. T. Wingate Todd, Cleveland, Ohio; Dr. Fred H. Albee, New York City; Dr. J. Warren White, Greenville, South Carolina; Dr. Roger Anderson, Seattle, Washington; and Dr. J. E. M. Thomson and Dr. C. Fred Ferciot, Lincoln, Nebraska.

The officers for the ensuing year are:

President: Dr. A. Bruce Gill, Philadelphia, Pennsylvania.
President-Elect: Dr. John C. Wilson, Los Angeles, California.
Vice-President: Dr. Philip Lewin, Chicago, Illinois.
Treasurer: Dr. E. Bishop Mumford, Indianapolis, Indiana.
Secretary: Dr. Carl E. Badgley, Ann Arbor, Michigan.

The next meeting will be held in Los Angeles, California, on January 16, 17, 18, 19, and 20, 1938.

In connection with the meeting of the **American Medical Association** at Atlantic City, June 9, 10, and 11, the following program has been arranged for the Section on Orthopaedic Surgery.

WEDNESDAY, JUNE 9

Comparison of Treatments and Their Results in Fractures of the Shaft of the Femur.
Dr. E. L. Eliason, Philadelphia, Pennsylvania.
End Result of Twenty-One Years of Spine Fusion for Tuberculosis.
Dr. W. H. Von Lackum, New York City.
The Etiology of Cartilaginous Exostoses and Giant-Cell Tumors of the Bone.
Dr. J. Dewey Bisgard, Omaha, Nebraska.
The Dynamic Biological Relativity of Nerve, Muscle, and Bone Pressure during Growth and Maturity.
Dr. Eben J. Carey, Milwaukee, Wisconsin. (By invitation.)
The Importance of Adequate Fracture Treatment in Rural Hospitals.
Dr. W. T. Hammond, Easton, Maryland.
A Comparative Study of the Surgical and Non-Operative Methods of Treating Bone and Joint Tuberculosis.
Dr. Leo Mayer, New York City.

THURSDAY, JUNE 10

Intervertebral-Disc Lesions.
Dr. W. J. Mixter, Dr. J. S. Barr, and Dr. A. O. Hampton, Boston, Massachusetts.
The Neurological Significance of Low-Back Pain.
Dr. R. G. Spurling and Dr. F. H. Mayfield, Louisville, Kentucky.
The Relation of Fascia Lata to Low-Back Conditions.
Dr. Frank R. Ober, Boston, Massachusetts.
Differential Diagnosis in Low-Back Pain.
Dr. Arthur Steindler, Iowa City, Iowa.
Arthrodesis in Osteo-Arthritis of the Hip.
Mr. R. Watson Jones, Liverpool, England. (By invitation.)
The Treatment of Chronic Arthritis of the Foot.
Dr. John G. Kuhns, Boston, Massachusetts.

FRIDAY, JUNE 11

Pathological Fractures.
Dr. Ralph K. Ghormley, Rochester, Minnesota.
The Occurrence of an Osseous Dyscrasia in Gastrectomized Puppies.
Dr. A. C. Ivy, Chicago, Illinois.
Dr. R. A. Bussabarger and Dr. Smith Freeman, Chicago, Illinois. (By invitation.)
Malunited Colles' Fractures.
Dr. Willis C. Campbell, Memphis, Tennessee.
Chairman's Address.
Dr. Fremont A. Chandler, Chicago, Illinois.
Simplified Technique of Onlay Grafts for All Ununited Fractures in Acceptable Position.
Dr. D. B. Phemister, Chicago, Illinois.
Fractures of the Os Calcis.
Dr. H. W. Spiers, Los Angeles, California.

The Chairman of the Section on Orthopaedic Surgery is Dr. Fremont A. Chandler, Chicago, Illinois, and the Secretary is Dr. Robert V. Funsten, University of Virginia Hospital, University, Virginia, to whom all requests for information should be addressed.

On February 11, 1937, Mr. Walter Mercer, M.B., Ch.B., F.R.C.S. (Edin.) F.R.S. (Edin.), of Edinburgh, delivered The **Lady Jones Lecture** in Orthopaedic Surgery at the University of Liverpool. The title of Mr. Mercer's address was "Anomalies of the Fifth Lumbar Vertebra: Reflections and Experiences".

Under the auspices of the **Gesellschaft der Ärzte in Wien** and the **Verein zur Förderung des ärztlichen Fortbildungswesens an der Universität Wien** an "*Ärztliche Festwochen*" has been arranged. This celebration takes place from May 19 to 29 and marks the one-hundredth anniversary of the founding of the former Society. Courses of lectures covering all branches of medicine will be given. Of interest to orthopaedic surgeons will be the addresses of Prof. Dr. F. v. Müller, of Munich, on "The Arthritic Diathesis" and Prof. Dr. E. Payr, of Leipzig, on "The Chief Methods of Overcoming Hypertension in Injuries and Diseases of the Joints".

The Annual Meeting of **La Réunion d'Orthopédie et de Chirurgie de l'Appareil Moteur de Bordeaux** was held on November 26, 1936, at which time members and guests presented papers on subjects of particular interest to the orthopaedic and the traumatic surgeon. The following papers were presented:

Extra-Articular Arthrodesis of the Hip in the Treatment of Coxalgia—Dr. H. L. Rocher.

Recurrent Fracture of the Patella—Dr. Ch. Lasserre.

Arthrodesis of the Tibiotarsal Articulation in Post-Traumatic Arthritis—Dr. Ch. Lasserre.

Platyspondylisis—Dr. R. Guerin.

Myeloplaxoma of the Axis—Dr. Y. Bourde (Marseilles).

Complicated Fractures of the Leg—Dr. Pr. Roques (Marseilles).

Two Cases of Malunited Fracture Treated Surgically—Dr. Charry (Toulouse).

Osteochondroma of the Knee—Dr. Ch. Lasserre and Dr. Dotezac.

Congenital Atrophy of the Spinous Apophyses—Dr. Ed. Papin.

Treatment of Epiphysiolysis—Dr. H. L. Rocher, Dr. R. Guerin, and Dr. L. Pouyanne.

Double Sacro-Iliac Arthrodesis—Dr. Charbonnel and Dr. Masse.

Pes Cavus Treated by the Phelps-Salaverri Operation—Dr. L. Pouyanne and Dr. H. L. Rocher.

Coxitis and Congenital Lesions—Dr. P. Forton.

Recurrent Luxation of the Patella—Dr. R. Dieulafé (Toulouse).

Amputation of Both Forearms in a Fourteen-Year-Old Boy and Condition of the Patient After Four Months of Reeducation—Dr. Dijonneau.

These papers have been published in the *Journal de Médecine de Bordeaux et du Sud-Ouest*, the issue of February 20, 1937.

The following have been elected to membership in the Society:

Honorary Member: Dr. Oudard, Toulon.

Corresponding Members: Dr. Solcard, Toulon; Dr. Roques, Marseilles; Dr. Clavelin, Val de Grace.

CORRECTION

Dr. Henry Milch of New York has asked us to publish the following:

"In my recent article on Epiphysiolysis, in the January issue for 1937, page 114, a statement to the following effect appears:

"'While the early results appear quite satisfactory, the method must not be considered entirely innocuous, since in one case calcification of the capsule with complete loss of all motion was the outcome of the operation.'

"It has been called to my attention that the calcification of the capsule in the case mentioned was improperly attributed to the drilling and was, in truth, due not to drilling, but to manipulation and other procedures.

"I regret that this inaccuracy should have appeared in my article, which, of course, was concerned primarily with the interpretation of the wide epiphyseal line, rather than the indications for, or the value of, any specific therapeutic measures."

Current Literature

Physiologie générale des articulations à l'état normal et pathologique (General Physiology of Normal and Pathological Articulations). A. Policard, Paris, Masson et Cie, 1936. 36 francs.

As a consequence of the efforts of many observers, a vast amount of information on the form and functions of specific joints has been accumulated. Unfortunately, most of these data are scattered in journals not readily accessible to the orthopaedic surgeon to whom they are of vital and incalculable importance. The author has culled the more significant of these contributions with the object of establishing the anatomy and physiology of "an articulation in general, the tissues which constitute it, the fundamental mechanics which play their part in it, the conditions of its nutrition".

The present volume, consisting of 209 pages, is subdivided into seven chapters which treat specifically of the articular cartilage, the accessory fibrocartilages, the synovial membrane, the joint proper and the synovial fluid, the capsule and the articular ligaments, the innervation of the joint, and the periarticular connective tissue. The first chapter on the articular cartilage is based largely upon the work of Benninghof and gives an excellent discussion of the minuter structure and histophysiology of hyaline cartilage. The relative importance of the intracellular substance and of the fibrillar network which determines the essential physiological value of the hyaline cartilage is described with painstaking detail. The nutrition, the functional destruction of the hyaline cartilage, its normal histomechanics, the question of the growth and regeneration of adult cartilage, and, finally, the pathological processes of fissuring, softening, and chondromalacia are each treated with characteristic French lucidity and brevity. The chapters on the synovial membrane and the synovia, in which the author follows the work of Hammar, are almost, if not quite, as stimulating as the earlier part of the work. Throughout the author stresses the fact that in their anatomical arrangement, in their physiological adaptation, and in their pathological reaction, the joint and the synovial membrane betray their connective-tissue, mesenchymal origin. It is only upon the acceptance of this fundamental concept that the various data can be unified and assimilated.

It is to be regretted that in these, as in the other portions of his work, the emphasis has been laid more upon the normal biology of the joint, while only relatively slight space has been allotted to a sketchy outline of pathological conditions. It is further to be regretted that several additional drawings to clarify the textual description of the anatomy at transition points—*e.g.*, between the hyaline cartilage and the synovial membrane—have not been given. But these few faults are more than compensated for by a terse, but freely flowing literary style which is as exhilarating in elucidating what is already known as in indicating problems yet to be solved. To the orthopaedic surgeon, almost overwhelmed by a rapidly accumulating mass of detail, this volume will come as a sort of intellectual oasis in which he may refresh himself by substituting broad, general principles for the minutiae of daily application.

The Physiological Basis of Medical Practice. Charles Herbert Best, M.D., D.Sc. (Lond.), F.R.S., F.R.C.P., and Norman Burke Taylor, M.D., F.R.S., F.R.C.S. (Edin.), F.R.C.P., M.R.C.S. (Eng.), L.R.C.P. (Lond.). Baltimore, William Wood & Co., 1937. $10.00.

The subtitle to this very complete text-book is "A University of Toronto Text in Applied Physiology". In the preface the authors state: "We have endeavored to write a book which will serve to link the laboratory and the clinic, and which will therefore promote continuity of physiological teaching throughout the preclinical and clinical years of

the under-graduate course." This is in keeping with modern tendencies in medical teaching. No student in a four years' medical course can digest the vast amount of knowledge which has accumulated in the basic medical sciences. What particularly concerns him in his future practice must be extracted for him at the cost of his formal knowledge.

As a text-book of 1519 pages, written for medical students whose chief interest is assumed to be in the diagnosis and treatment of disease, it errs possibly on the side of being too massive. Starling's "Human Physiology" has been criticized for the same reason. An excellent feature is the inclusion of short descriptions of diseases with their physiological background. It is modern in the sense that it includes, for example, considerations of the sedimentation rate of red blood cells, of the action of methylene blue in cyanide poisoning, of protamine insulin, of obesity, and of female sex hormones. An excellent section of 303 pages on the nervous system is included. Students preparing for examinations will be grateful for the terse description of Horner's syndrome. Such a treatise, covering all systems of the body with a double purpose, may not please every reader. For example, some would prefer a more complete handling of the modern knowledge of ascorbic acid, and many would not agree that the influence of the spleen in regulating blood volume in man is of as great importance as the authors indicate.

The book is written carefully and makes pleasurable reading. The touch of sober drama—the descriptions of Head's experiment upon himself, and of Lind's research on scurvy in 1747—is not a disadvantage. This will unquestionably become an important text-book in many medical schools. It will be very useful to the practitioner of medicine who is desirous of keeping up to date his theoretical knowledge and of applying physiological principles in his practice.

DIE PYOGENEN INFEKTIONEN UND IHRE BEHANDLUNG (Pyogenic Infections and Their Treatment). Erich Lexer. (Neue deutsche Chirurgie, 56. Band.) Stuttgart, Ferdinand Enke, 1936. 12.80 marks.

Lexer reiterates his classification of conditions familiarly referred to as "sepsis", "septicaemia", and "pyaemia". Excluding putrid and specific infections, he supplants such vague terms by classifying generalized pyogenic infection, whose cause is usually staphylococcal or streptococcal, into forms with and without metastases. The metastatic form is either purely bacterial or thrombo-embolic; that without metastases, either bacterial or toxic. Treatment is directed toward removal of the infecting agent and increased resistance of the host. Discussion of this occupies the first part of the book and is taken from his work on generalized pyogenic infections and their treatment, reviewed in the January 1937 issue of *The Journal of Bone and Joint Surgery*.

Localized pyogenic infections are to be treated by excision of the tissue boundaries of the affected area within the limits of bacterial incubation time, most often from six to eight hours. Lexer states that there are four primary principles to be borne in mind in attacking and checking the spread of localized pyogenic infections: (1) increase of general resistance; (2) reenforcement of local defense processes; (3) operative exposure of the sources of infection,—primary and secondary, lymphatic and hematogenous; and (4) immobilization of the affected regions.

Generalized resistance is best increased by blood transfusion. Antiserums, vaccines, bacteriolysins, non-specific protein therapy, creation of a sterile abscess, and chemotherapy may be of more value when the infection is still localized than when it has become generalized.

Reenforcement of local tissue defense is gained in many cases through Bier's passive hyperaemia. On the other hand, active hyperaemia is useful following regression of the acute stage. Although less useful in suppurative osteomyelitis, the x-ray has been seen to cause regression of simple periosteal abscesses before roentgenographically visible bone changes occur.

For the third principle, "the earlier and the better the first inflammatory areas are

exposed, the more reliable will be recovery and the more safely will latent sources of infection be avoided". Coagulation of an infective area by heat or by electricity is criticized; electrosurgical incision may be superior to simple incision and requires no tourniquet ischaemia. Spread of infection through early exposure does not occur when the incision does not infringe on the zone of protective reaction; the incision should be lightly packed with iodoform gauze for twenty-four hours, with or without drainage tubes, to promote capillary drainage.

The principle of immobilization and rest with elevation of the affected region is of the utmost importance. Dressings may be changed as often as necessary, but with minimal disturbance of the wound surface and the protective barrier of granulation tissue.

Lexer then discusses the therapy of certain forms of pyogenic infection,—suppurative arthritis and pyogenic infections of bone, the lymphatic channels, and serous cavities.

The observations which Prof. Lexer is able to give from his long and varied experience will serve as a valuable guide to any surgeon who has to deal with these problems.

LOMBOARTRITE E SCIATICA VERTEBRALE. V. Putti. Bologna, L. Cappelli, 1936.

Within the short span of one year, Prof. Putti has added to his excellent work on the pathology of the congenital dislocation of the hip a no less remarkable monograph on the lumbosacralgias or low-back pain. It is the result of twenty years' observation and study of 1121 cases.

Following his conception of "neurodokitis", the author gives a detailed consideration of the anatomy of the nerve supply to the intervertebral canal and intervertebral articulations. With a great deal of plausibility he rejects the older ideas of the significance of the transverse process and sacralization. If sacralization causes disturbance, it is the effect of arthritis in the newly formed articulation. He thinks the same of the so called tropism. On the other hand, an ordinary acute lumbago is an eminently articular syndrome, not a muscular syndrome. He also speaks of a definitely traumatic lumbago of sudden onset, as distinct from the arthralgic form. There is a lumbalgia entirely confined to the back, exquisitely localized, in contrast to the radiating form of sciatica. Instructive roentgenograms and anatomical specimens, showing definite osteo-arthritic changes of the intervertebral articulations, are included. He discusses in detail the sciatic scoliosis which he ascribes to a vertebral unilateral arthritis. He takes issue with Sicard's conception of radiculitis in cases in which the roentgenogram shows arthritic changes in the articulations, believing that the latter are the principal causes of the pain syndrome. He gives statistics on reflex changes (deep 30 per cent., superficial 0.89 per cent.), motor disturbances (8.5 per cent.), and muscle atrophy (51.56 per cent.), and discusses the differential diagnosis of intraspinous lesions, spondylosis, Pott's disease, tumors, sacro-iliac disease, hip disease, etc.

In the chapter on treatment, physical therapy, especially hot-air treatment, is emphasized, while diathermy and short-wave treatment are strongly rejected. As he has done in previous publications, the author again emphasizes immobilization by cast as the paramount measure. No place is given to manipulation. On the operative side, he mentions and describes with the aid of excellent illustrations the transversectomy for painful sacralization and the technique of the resection of a posteriorly herniated intervertebral disc. A short chapter is devoted to cervicothoracic brachialgia.

The book is magnificently illustrated. The anatomical and pathological material underlying this study is not only abundant but it is also utilized with painstaking care and thoroughness. The reader will be strongly attracted by the brilliancy of diction and clearness of presentation. The work is a milestone in the study of low-back disorders.

RECENT ADVANCES IN ORTHOPAEDIC SURGERY. B. H. Burns, F.R.C.S., and V. H. Ellis, F.R.C.S. Philadelphia, P. Blakiston's Son & Co., Inc., 1937. $5.00.

This interesting volume of moderate size makes some attempt to bridge the gap between the text-book on orthopaedic surgery and the more recent literature. There is no

attempt to bring the knowledge of *all* the various orthopaedic diseases up to date and in certain notable instances the omissions are really glaring. For instance, the chapter on Anterior Poliomyelitis dismisses tendon transplantation with a few lines, which suggests that this procedure has fallen into disrepute. The only operative procedure specifically described in this chapter is Lambrinudi's modification of the triple arthrodesis for foot stabilization.

However, the reviewer found the discussion of most of the topics to be fresh, interesting, and sane, and he predicts that the reader will be repaid by discovering some "recent advances" which had previously eluded his attention.

The purpose of the book seems to be stated in these lines quoted from the preface: "Our views will, we hope, be helpful to some, whilst to others they may be an irritant, perhaps amounting to a stimulus". Their hopes will, the reviewer believes, be realized.

Quelques vérités premières (ou soi-disant telles) en chirurgie infantile. L. Ombrédanne. Paris, Masson et Cie, 1936. 24 francs.

In his daily clinical experience, the busy surgeon is constantly making observations, the accumulation of which form the basis of his increasing skill and judgment. This capacity of observation in forming an estimate of the value and significance of the signs and symptoms should be a part of the self training of every medical man. Very few, however, put themselves to the task of recording their ideas and their observations as they are made, so that their experience may be available to those who have less opportunity.

The author of this book has evidently applied himself to this task throughout a long experience, and has put into brief and almost axiomatic form certain truths which can be applied to the subject of the surgery of children. The book serves to emphasize many of these facts which are accepted, and to correct other conceptions which are not accurately founded. The author states that the truths of today may become the errors of tomorrow. The observations cover practically the whole field of the surgery of children, and they are grouped under the following headings: Generalities; Face and Neck; Head and Spine; Thorax and Abdomen; Genital Organs; and Limbs.

This book will be of great interest to those who have already had a great deal of experience, and of much help to those who have had less.

Source Book of Orthopaedics. Edgar M. Bick, M.A., M.D. Baltimore, The Williams & Wilkins Co., 1937. $4.00.

From a very extensive study of the literature of the world, Dr. Bick has given a most comprehensive story of the development of Orthopaedic Surgery, correlating from the earliest data on primitive man and his accomplishments the factors which have influenced the beginning and the rise of this special branch of Medicine. It is interesting to read of the struggles in that period and of the ingenuity shown in the use of the most primitive material, and with instinct instead of knowledge to guide. By grouping the results of his study into periods, the author demonstrates the gradual unfolding of this specialty and gives a glimpse of the changing opportunities in the different periods. The prominence given the facilities possible at that time in the treatment of fractures indicates the importance of these injuries in those early and troublesome times when the mere existence depended on protection by physical force. Under the more highly developed intellectual periods, art and the refined influences are shown to have played an important rôle.

The latter part of the book deals with the influence of the important factors on the growth of the special departments of Orthopaedic Surgery, and tribute is paid to those men whose special contributions toward the advancement of Orthopaedic Surgery made them famous for all time. Some of the more important problems, which are now prominent and are given more special attention, are discussed separately and in detail. This helps to set forth more clearly the present status of this specialty.

The book is so written that it makes enjoyable reading, and its thorough treatment of the subject gives satisfaction.

PREOPERATIVE AND POSTOPERATIVE TREATMENT. Robert L. Mason, A.B., M.D., F.A.C.S. Philadelphia and London, W. B. Saunders Co., 1937. $6.00.

The writer believes that "the good surgeon is primarily a good physician". Here is a surgical treatise of 495 pages without a word on surgical technique. Good preoperative study and treatment and proper postoperative treatment make the difference between poor and good surgery. The rapid developments in this field during the past decade warrant just such a book.

The plan and the arrangement of the material are excellent. The chapter on anaesthesia and the position of the patient on the operating table is especially well illustrated. Throughout the book the cuts and line drawings are good. Proper emphasis is laid on the various subjects treated and the book is well balanced. Certain chapters are written by specialists in their subjects,—an anaesthetist, internists, a cardiologist, a thoracic surgeon, a proctologist, a urologist, etc. These specialists have not only written sections on their subjects as a whole, but, in the second half of the book, they have written sections directly under the treatment of regional conditions. Such an arrangement emphasizes the fact that a good surgeon needs the assistance of such men throughout the course of the surgical treatment. As an example, the cardiologist and the diabetic internist have assisted in writing the section on the preoperative and postoperative care of the patient with hyperthyroidism.

The book opens with preliminary considerations of the history, physical examination, and laboratory studies. Then follow discussions on the conditions affecting the operative risk, the management of patients with heart disease, diabetes, hypertension or nephritis, anaesthesia, and the general preparation of the good-risk patient. Shock, transfusion, water balance and methods of administering fluids, adynamic ileus, and acute dilatation of the stomach are also considered. The care of the wound, the reasons for disruption of wounds, pulmonary complications, peritonitis, parotitis, thrombosis, and the treatment of burns are carefully described. In the second half, treatment is discussed under regions and specific conditions, as intestinal obstruction, appendicitis, hyperthyroidism, and urology.

THE HOME TREATMENT OF SPASTIC PARALYSIS. Percy Merritt Girard, M.D., F.A.C.S. Foreword by Earl R. Carlson. B.A., M.S., M.D. Philadelphia, J. B. Lippincott Co., 1937. $2.00.

This small volume of Dr. Girard's and its foreword by Dr. Carlson will come as a great boon to many a parent confronted with a problem that calls for a most discriminating understanding of child psychology, as well as the most persistent attention to the training of the unfortunate child, not merely in trying to educate refractory muscles, but in teaching him to forget his handicap, thus preventing the closure of channels for improvement, both mental and physical, that must go hand in hand. Better physical control, desirable as it is, will fall far short of what it might mean to the individual if at the same time areas of the brain, dependent upon stimuli that must come to them through impaired peripheral organs, are not specially cultivated.

The different subdivisions of the subject are adequately handled. Physical therapy, as applied to specific disabilities and deformities, is well considered and outlined. Occupational therapy, games, speech training, and methods of teaching relaxation and coordination are given their proper values and the attitude of parents and attendants toward the spastic and his or her attitude toward other children and society at large are properly emphasized.

This book should fill a long-felt want,—a want, it is to be feared, not as fully appreciated as it should be on the part of many physicians and others who are called upon to deal with these problems.

THE KINESIOLOGY OF CORRECTIVE EXERCISE. Gertrude Hawley, M.A. Philadelphia, Lea & Febiger, 1937. $2.75.

This book is planned as a practical text-book for those who are actually engaged in the problems of physiotherapy. The author has recognized the difficulties which are encountered in the daily routine of this work and the necessity of a more thorough understanding of the anatomy and of the normal function of the joints which have to do with this form of therapy. She has given a very excellent presentation of these subjects, with the object of aiding those engaged in this work to a better understanding of the application of the exercises which may be used. She has also recognized the difficulties in the choice of exercises given for the various conditions.

The second portion of the book is devoted to the presentation of the clinical part of the problem. It is helpful to have the object of the exercises defined, and to have the exercises for each condition described and grouped according to their use. These exercises are well illustrated by line drawings. Scoliosis and visceroptosis are each accorded a chapter, which places proper emphasis on the importance of these two subjects in the field of physiotherapy.

The author has evidently included many of her own methods and, although the treatment is quite definitely mapped out, it is not enough so to lead the physiotherapist to assume too much of the medical responsibility. The book presents much useful information which is fundamental to the physiotherapist, and contains many helpful suggestions.

JUVENILE PARESIS. William C. Menniger, M.D. The Menniger Clinic Monograph Series No. 1. Baltimore, The Williams & Wilkins Co., 1936. $3.00.

Juvenile paresis is a rare disease but one of considerable importance to the neurologist and the pediatrist. This monograph is a study of forty-three cases from the Menniger Clinic with 610 cases from the literature.

The subject is treated in a thorough manner, in orderly fashion, and written in a style easy to read. The chapter on "Physical Complications, Stigmas, and Endocrinopathies" is especially interesting. Treatment and pathology are discussed at length, and the section on pathology has some excellent illustrations. At the end of the monograph is a complete bibliography of 530 references.

INHALATION ANESTHESIA. A FUNDAMENTAL GUIDE. Arthur E. Guedel, M.D. New York, The Macmillan Co., 1937. $2.50.

Dr. Guedel, Associate Clinical Professor of Surgery (Anaesthesia) at the University of Southern California School of Medicine, has developed a valuable guide to the principles and practice of inhalation anaesthesia for the teachers of anaesthesia, graduate and under-graduate medical students, and physicians, specialists, or general practitioners. In this book may be found the answers to many problems arising in the general care of the patient in anaesthesia.

The book is divided into two parts: the principles of inhalation anaesthesia and anaesthesia accidents.

In the first part is a valuable detailed analysis of the physical signs of inhalation anaesthesia. Following this are discussions of the surgical reflexes, the potency of the various anaesthetic agents, the choice of pre-anaesthetic drugs, the preparation of the patient, and the selection of the anaesthetic agents.

In the second part of the book, Dr. Guedel covers the anaesthetic accidents quite completely. These include: changes in blood pressure, ventricular fibrillation, central and peripheral respiratory paralysis, reflex spasm, aspiration of debris, cyanosis, and anaesthetic explosions. The sources and prevention of anaesthetic explosions are also discussed.

This book gives the reader information on the principles of inhalation anaesthesia which he can readily put into practice.

The *Journal* wishes to acknowledge the receipt of the following publications sent to the Editorial Department:

Anales de Cirugía (Rosario), II, No. 4, 1936.

Boletim da Secretaria Geral de Saude e Assistencia (Rio de Janeiro), II, Núm. 4, 1936.

Bulletin of the National Tuberculosis Association, XXIII, Nos. 1 and 3, 1937.

The Child (Washington, D. C.), I, No. 6, 1936; Nos. 7 and 8, 1937.

Cirugía y Cirujanos (Mexico, D.F.), IV, Núms. 5 and 6, 1936; V, Núm. 1, 1937.

Cleveland Clinic Quarterly, IV, No. 1, 1937.

Current Medicine, IV, No. 2, 1937.

Diabetes und Chirurgie. Prof. Dr. A. W. Fischer. (Vorträge aus der praktischen Chirurgie, 12. Heft.) Stuttgart, Ferdinand Enke, 1937.

The Piedmont Hospital Bulletin, X, No. 1, 1937.

Social Statistics (The Child, Supplement No. 1), 1937.

Staphylococcus Stones. A Clinical Study of 90 Cases. John Hellström. (Acta Chirurgica Scandinavica, LXXIX, Supplementum XLVI.) Stockholm, 1936.

Surgery, I, No. 1, 1937.

Zur Frage der Hydronephrose bei Nierengefässvarianten unter besonderer Berücksichtigung ihrer Behandlung durch Gefässresektion. Seved Bergendal. (Acta Chirurgica Scandinavica, LXXIX, Supplementum XLV.) Lund, 1936.

ON THE ANATOMY AND PATHOLOGY OF THE HIP-JOINT. Poul Morville. *Acta Orthopaedica Scandinavica*, VII, 107, 1936.

Flat acetabulum has been suggested as a cause of hip disorders by several writers and by Dr. Morville in a previous paper (*Acta Orthopaedica Scandinavica* IV, 133, 1933). His present paper is based on the injection of the hips of twelve stillborn babies, and a study of the roentgenograms of 100 patients with osteo-arthritis and of thirty patients who were admitted for hypertrophied prostates.

The femoral head is normally too large for the shallow socket at birth. The progressive deepening of the acetabulum, the changes in the axis of the neck, and the position of the epiphysis are shown diagrammatically from birth to nine years. Instead of the term "congenitally flat acetabulum", the writer suggests the phrase "acetabulum which remains flat".

He further groups hip lesions into constructive (luxation, subluxation, and coxa valga) and structural (coxa plana, "slipping" epiphysis, and acquired subluxation). Osteo-arthritis of the hip is developed on the basis of subluxation of the congenital or of the acquired type. Examples are given, and the treatment is discussed.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

ON THE TREATMENT OF TUBERCULOUS SPONDYLITIS IN CHILDREN. H. Wahren. *Acta Orthopaedica Scandinavica*, VII, 177, 1936.

Twenty-four cases of tuberculosis of the spine of children under fourteen years of age were observed for from two to fourteen years following the dates of the fusion operations. The patients were kept in plaster beds until the lesions were no longer progressive and were then operated upon according to Albee's technique. After from two to three months more on plaster beds, plaster jackets were supplied. In most of the cases the patients were supported also by leather jackets.

One child of seven years died immediately following the operation, and one of eight years, three years after the operation. The remaining results are tabulated as: good, fifteen; fair, two; and bad, one. There were five cases of fracture of the graft and two of fracture of the tibia. Further progress of the lesion followed the operation in three cases. A relationship between kyphosis juvenilis and tuberculous spondylitis was suggested by one case in which typical wedging of the thoracic vertebrae was observed six years following the fusion operation at fifteen years of age.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

Synovial Sarcoma. Leila Charlton Knox. *The American Journal of Cancer*, XXVIII, 461, Nov. 1936.

The author carefully reviews the literature of this rare tumor and collects nineteen cases, to which she adds three cases from St. Luke's Hospital. "Malignant tumors of the joints, bursae, and tendons may usually be separated into one of two groups, fibrosarcoma or synovial sarcoma." The latter are recognized at operation by the soft cellular quality of the tumor and the usual presence of bluish, cystic spaces with a slightly gelatinous ground substance. Microscopically they present "epithelial-like cells lining tubules, pseudo glands or clefts, outside of which exists a dense felt-work of connective tissue".

Clinically, pain or swelling and tenderness of a joint were the commonest early symptoms. The knee joint was involved nine times; the popliteal region, three times; and the forearm, twice. The prognosis is unfavorable even with early amputation. More than half of the cases occur in patients less than thirty years of age. In all of the author's cases, pulmonary or pleural metastases developed. It is unlikely that radiotherapy will prove effective.

The paper is well illustrated with photomicrographs showing the histological characteristics detailed in the text.—*Grantley W. Taylor, M.D., Boston, Massachusetts.*

Synovioma of the Hand. Report of a Case. William C. Black. *The American Journal of Cancer*, XXVIII, 481, Nov. 1936.

The author reports a synovioma of the thumb in an engineer, thirty-six years of age. Trauma may have played some part in the etiology. At operation the tumor appeared to be encapsulated. Histologically the tumor displayed typical characteristics. There has been no recurrence six months after operation.—*Grantley W. Taylor, M.D., Boston, Massachusetts.*

Significance of Increased Phosphatase Activity of Bone at the Site of Osteoplastic Metastases Secondary to Carcinoma of the Prostate Gland. Ethel B. Gutman, Edith E. Sproul, and Alexander B. Gutman. *The American Journal of Cancer*, XXVIII, 485, Nov. 1936.

The authors report a series of phosphatase determinations made by the King and Armstrong method. Determinations were carried out on normal bone, on bone presenting osteoplastic metastases from carcinoma of the prostate, on various other types of diseased bone, as well as both "acid" and "alkaline" phosphatase of normal prostate-gland tissue. They feel that the increased serum-phosphatase activity in various conditions is due to the escape of increased amounts of phosphatase from the areas of bone activity. High bone phosphatase associated with osteoplastic carcinomatous metastases probably causes the new bone formation. The authors believe that certain chemical factors elaborated by some metastatic-tumor cells initiate the osteoplastic type of response, and they raise the question whether the large amounts of "acid" phosphatase in metastases from prostatic carcinoma may have any bearing on the production of "alkaline" phosphatase and the osteoplastic tendencies of prostatic carcinoma metastases.—*Grantley W. Taylor, M.D., Boston, Massachusetts.*

Lymphosarcoma of the Mediastinum with Metastases to the Skeleton. Report of a Case. William S. Middleton, Ernst A. Pohle, and Gorton Ritchie. *The American Journal of Cancer*, XXVIII, 559, Nov. 1936.

The authors report a large mediastinal lymphosarcoma in a young man of sixteen, with areas of metastatic disease in the liver, the skull, the right humerus, and the right ilium. Radiation therapy brought about extensive necrosis of the primary lesion and relief from pain due to the osseous metastases. In spite of these regressions, the disease ran a rapid course to a fatal termination.—*Grantley W. Taylor, M.D., Boston, Massachusetts.*

CLINICALLY DEMONSTRABLE BONE CHANGES IN LEUKEMIA. Charles L. Connor. *The American Journal of Cancer*, XXIX, 20, Jan. 1937.

The author reports two cases of lymphatic leukemia associated with marked bone changes, with roentgenograms. Such cases are uncommon, but may give rise to confusion in diagnosis. The lesions are most frequent in the pelvic bones, the spine, the upper ends of the femora, and the humeri. They occur chiefly in children.

There is a careful review of the literature, leading the author to the conclusion that "the outstanding signs of some leukemias may be pain around the joints, resembling rheumatic arthritis; pain in the long bones as in osteomyelitis; periosteal reactions as in scurvy, periostitis, or luetic periostitis; spontaneous fracture in local osteolytic processes; bulky tumors of single bones; osteolytic lesions, as in myeloma or chloroma".—*Grantley W. Taylor, M.D., Boston, Massachusetts.*

CORRELATION OF PATHOLOGIC AND ROENTGENOLOGIC FINDINGS IN TUBERCULOSIS AND PYOGENIC INFECTIONS OF THE VERTEBRAE. THE FATE OF THE INTERVERTEBRAL DISC. Edward L. Compere and Monroe Garrison. *Annals of Surgery*, CIV, 1038, Dec. 1936.

The vertebral body is richly supplied with nutrient arteries which penetrate the cortex, but do not cross the articular surfaces, while the intervertebral disc, on the other hand, has no blood supply in the adult, nutrition being supplied by the lymphatic system. The fibrocartilaginous annulus blends intimately with the hyaline-cartilage plates above and below, enclosing the nucleus pulposus, the semigelatinous substance of which is incompressible and its narrowing must therefore be obtained by dehydration, extrusion, or destruction.

Vertebral tuberculosis most commonly arises from a hematogenous implant in the spongiosa or compacta of the body, usually in the metaphysis with slow erosion into the cartilage. Such a lesion may be too small to be recognized in the roentgenogram until after the prolapse of the nucleus and destruction of the disc.

In pyogenic infection, the primary focus is in the bone, but the disc is less able to survive the attack, as demonstrated by early roentgenographic evidence. The cartilage plate is rapidly destroyed by the proteolytic enzymes, the nuclear substance is extruded, and the fibrous annulus also undergoes dissolution. The onset is rapid, the duration short, and the symptoms severe. When the infection subsides, there is regeneration of bone, and bony ankylosis occurs more often and more rapidly than in tuberculosis of the spine. Pyogenic infection may spread by direct extension through an intervertebral disc from body to body, but this was not found by the authors in their cases of vertebral tuberculosis. In the latter, spread by extension occurred under the anterior longitudinal ligaments with surface invasion of bone.

Secondary pyogenic infection is a frequent complication, characterized by sinus formation, amyloid disease, and death. The pathological changes may be typical either of tuberculosis or of pyogenic osteomyelitis, or of a combination of the two.

Nine cases are reported, which are excellently illustrated with some forty-two photographic and roentgenographic studies of gross specimens and microscopic sections.—*Norman T. Kirk, M.D., San Francisco, California.*

HYPERPARATHYROIDISM IN SIBLINGS. Leon Goldman and Francis S. Smyth. *Annals of Surgery*, CIV, 971, Dec. 1936.

Primary hyperparathyroidism is a clinical entity, caused by one or more parathyroid adenomata, and has a definite train of clinical, metabolic, and roentgenographic findings, on which the diagnosis is based.

Three important types of parathyroid hyperfunction are recognized:

1. The adenoma, associated with and causing generalized osteitis fibrosa cystica. In the two cases reported this type is characterized by demineralization of the entire skeleton, multiple cyst formation, pathological fracture, hypotonicity of muscle, high

blood calcium and phosphatase and low phosphorus content with a marked negative calcium balance.

2. Hyperplastic type, associated with renal calculi showing high serum calcium, low phosphorus, and no skeletal changes. As reported by Albright, these cases were improved by removal of enlarged hypertrophic parathyroid glands of various sizes.

3. The secondary or compensatory type, in which parathyroidectomy is not indicated, associated with such diseases as arthritis, osteitis deformans, multiple myeloma, metastatic carcinoma, and rickets.

The two cases reported are excellently illustrated, and have been thoroughly studied both preoperatively and postoperatively.—*Norman T. Kirk, M.D., San Francisco, California.*

SUBCHONDRAL TUBERCULOUS SEQUESTRA. Jerome G. Finder. *Annals of Surgery,* CIV, 1080, Dec. 1936.

A six-year review of material seen in Dr. Arthur Steindler's Clinic, a statistical analysis of eighty-six clinically recognized cases, and a histopathologic study of twenty anatomical specimens serve as a basis for the author's conclusions.

The sequestrum is a subchondral tuberculous necrosis appearing roentgenographically as a wedge-shaped area of increased density, not lying "free" as does a pyogenic sequestrum. The density may be caused by deposits of lime salt in tuberculous caseous material, or by lack of absorption of bone in the necrotic focus, while the surrounding living bone becomes porotic and the picture may be confused by hypertrophic arthritis. The diagnosis is simple and absolute only when the focus is separated and extended toward or into the joint. It is often a diagnostic feature of joint tuberculosis.

Bone infection is usually secondary to joint disease, being primary in only 20 per cent. of the cases in this study, invasion occurring at the joint margin where the cartilage is thin. The infarct type of wedge necrosis of bone, due to vascular occlusion, occurs rarely.

The sequestrum when formed can be changed only by: (1) trauma (it is extruded into the joint and ground into fragments or expelled through a sinus); or (2) molecular disintegration. It may be encapsulated in fibrous tissue and remain unchanged indefinitely.

The article is excellently illustrated with some thirty-six histopathological and roentgenographic reproductions.—*Norman T. Kirk, M.D., San Francisco, California.*

A COMPARATIVE RADIOLOGICAL STUDY OF THE BONY CHANGES IN ACHONDROPLASIA, ACROMEGALY, PAGET'S DISEASE, LEONTIASIS OSSEA, CRANIO-CLEIDO-DYSOSTOSIS, DIAPHYSEAL ACALASIA, PERTHES' DISEASE AND FRAGILITAS OSSEA. M. J. S. Pillai. *The Antiseptic,* XXXIII, 741, 1936.

Pillai reports from the Barnard Institute of Radiology at Madras a comparative study of the bone changes in achondroplasia, acromegaly, Paget's disease, leontiasis ossea, cleidocranial dysostosis, diaphyseal acalasia, Perthes' disease, and fragilitas ossea. The report is illustrated by a series of thirty-two x-ray reproductions. The author discusses several problems suggested by his study: notably the part played by the parathyroids in the calcium metabolism of dwarfism and gigantism; the possible superimposition of acromegaly on gigantism; the relation of Paget's disease to dystrophy of the endocrine system; the relation of the endocrine system to osteomalacia and to fragilitas ossea. The author also emphasizes the importance of discovering methods for determining the presence and the exact amount of endocrines and vitamins in the blood stream, as a means of explaining satisfactorily various of the developmental malconditions which he has studied.—*Robert M. Green, M.D., Boston, Massachusetts.*

BRITTLE BONES AND BLUE SCLERAS IN FIVE GENERATIONS. Ralph G. Hills and Samuel McLanahan. *Archives of Internal Medicine,* LIX, 41, Jan. 1937.

The authors report the case of a white girl, aged ten years, who had multiple fractures, dislocation of the hip, and blue sclera. Data were obtained concerning fifty mem-

bers of the patient's family, in twenty-six of whom the main features of the disease were present. Four distinct features of this syndrome are emphasized: fragile bones, blue sclera, a tendency to deafness, and relaxation of the ligaments. Affected subjects tend to be short and slender. The etiology is unknown. The syndrome is best described as a hereditary hypoplasia of the mesenchyma and follows the mendelian law of inheritance, appearing as a dominant character. There is no specific treatment other than protection from injury and treatment of fractures which apparently heal satisfactorily. The fractures tend to occur throughout childhood until puberty is reached. The disease is to be distinguished from a large group of non-hereditary conditions of different etiologies, associated with soft or brittle bones,—for example, osteoporosis, osteomalacia, metastases to bones, hyperparathyroidism.—*Clark W. Heath, M.D., Boston, Massachusetts.*

ACUTE HEMATOGENOUS OSTEOMYELITIS. CLASSIFICATION OF THE CASES OF ACUTE HEMATOGENOUS OSTEOMYELITIS AS DETERMINED BY THERAPEUTIC INDICATIONS; RESULTS OF OPERATIVE TREATMENT. Abraham O. Wilensky. *Archives of Surgery,* XXXIV, 320, Feb. 1937.

Wilensky stresses the fact that acute hematogenous osteomyelitis is not to be treated by routine operative procedures. The condition is a manifestation of a septicaemia and should be treated as a systemic disease. He reports cases in which conservatism was rewarded by satisfactory results. In other instances, in spite of radical drainage of the bony lesion, the blood infection produced fatal results. He also calls attention to the fact that surgical manipulation of an osteomyelitic focus may reawaken a septicaemia that has come under control.—*I. William Nachlas, M.D., Baltimore, Maryland.*

SCIATIC PAIN AND ITS RELIEF BY OPERATIONS ON MUSCLE AND FASCIA. Albert H. Freiberg. *Archives of Surgery,* XXXIV, 337, Feb. 1937.

When the piriformis muscle is under tension it can, through its contiguity with the fibers that make up the sciatic nerve, produce a sciatica. The tension may result from muscle spasm incidental to disease of the sacro-iliac joint (which it bridges) or to disease of the muscle itself. The positive response in the Lasègue test and the symptomatic relief obtained by subperiosteal stripping of the gluteus maximus or by fasciotomy of the fascia lata can be traced to changes in the tension of the piriformis. In addition to this, section of the piriformis, an operation which more directly attacks the cause of the sciatica, has been tried and found successful. Although only three such cases are reported, it is implied that other such operations have been performed, with satisfactory results. It is emphasized that complete studies of the factors causing the muscle spasm are necessary before symptomatic relief may be obtained by myofascial operations which release the piriformis tension.—*I. William Nachlas, M.D., Baltimore, Maryland.*

ROTATION AT THE SHOULDER. A CRITICAL INQUIRY. Lee McGregor. *British Journal of Surgery,* XXIV, 425, Jan. 1937.

On the basis of a careful study of the anatomy and physiology of the shoulder, certain important deductions have been made in regard to the surgery of the region. Many excellent illustrations accompany the text. The author concludes:

1. The shoulder joint is overhung by a closely applied osseofibrous arch.
2. There is room for normal joint movements only beneath this arch and any periarticular swelling means restriction in the motion, with pain.
3. Outward rotation of the humerus is an essential part of the movements of abduction above the horizontal plane.
4. Inward rotation is essential for full flexion.
5. With the arm vertical, no rotation of the humerus is possible.
6. Horizontal abduction in the frontal plane, combined with full external rotation of the arm, is a movement seldom used and, if used, causes discomfort. This position should not be employed in fixing the humerus. The midposition is more comfortable and more satisfactory.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

Pathological Fracture of the Humerus Complicating Late Secondary Syphilis. H. Jackson Burrows. *British Journal of Surgery*, XXIV, 452, Jan. 1937.

This is a case report of a patient with acquired syphilis treated actively from its onset. The first knowledge of bone involvement came with a pathological fracture from throwing a skittle ball. Roentgenograms showed extensive bone involvement. Healing occurred in the fracture, and seventeen months later all bones appeared normal by x-ray. The suggestion is made that the extensive bone changes were caused by the treatment rather than by the disease.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

A Comparison of the Results of Spinal Fixation Operations and Non-Operative Treatment in Pott's Disease in Adults. G. K. McKee. *British Journal of Surgery*, XXIV, 456, Jan. 1937.

The results of 100 cases treated by non-operative means have been compared with fifty cases treated by fixation operations. All lesions were in the thoracic or lumbar regions in patients, sixteen years or older, at the onset of the disease. All patients in the series were in the early stages of the disease and all were treated in the same sanatorium. Patients treated without operation were treated by fixation for eighteen months and in the operated cases fixation was maintained for twelve months.

In the non-operative group, 62 per cent. showed good roentgenographic results; 70 per cent., good clinical results; and 4 per cent., late abscess formation. In the operative group, 38 per cent. showed good roentgenographic results; 32 per cent., good clinical results; and 40 per cent., late abscesses.

The author concludes that spinal operations during the active stage of Pott's disease retard healing and that the only field of operative work in the late stages lies in the correction of deformity.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

Lesioni ostetriche della spalla (Birth Lesions of the Shoulder). O. Scaglietti. *La Chirurgia degli Organi di Movimento*, XXII, 183, 1936.

Five different theories concerning the etiology of birth lesions of the shoulder have been found in the literature: (1) lesion of the roots of the brachial plexus during birth; (2) lesion of the scapulohumeral joint during birth; (3) combination of both; (4) lesion during foetal life; and (5) infectious disease during foetal life or during the first days after birth (poliomyelitis or non-specific chronic affection). Of these theories, the first seems to be the most acceptable in the author's opinion.

One hundred and ninety-nine cases from Putti's Clinic are reported. The lesion was unilateral in 186 cases (93.46 per cent.) and bilateral in thirteen cases (6.53 per cent.). Of the 186 unilateral cases, the lesion affected the right shoulder in 125 (62.81 per cent.) and the left in sixty-one (30.65 per cent.). The male sex predominated: there were 110 males (55.27 per cent.) and eighty-nine females (44.72 per cent.).

The fact that the OLA position is the most frequent and that the shoulder of the child is pressed in this position against the pubic bone of the mother is the reason for the preferred occurrence of the lesion on the right side. Three groups of birth lesions are to be distinguished: (1) joint lesions; (2) palsies; and (3) combinations of both. Electrodiagnostic and roentgenographic examinations reveal the type.

Among the articular lesions, the most frequent was a medial and posterior displacement of the head of the humerus. The therapy in these cases was always operative, performed in two steps,—first, Sever's capsulotomy; second, Putti's "derotation" osteotomy. The space between the pectoralis major and deltoid muscles is incised, and the upper portion of the humerus is exposed, care being taken not to injure the circumflex nerve. The second part of the procedure consists of osteotomy of the surgical neck and rotation of the lower fragment in various degrees, depending upon the previous inversion.

The therapy in birth-palsy cases was always conservative,—electrotherapy, massage, and the application of an abduction splint.—*J. Wolf, M.D., Iowa City, Iowa.*

La corrección y cura de las deformidades del raquis y su relación con el menisc intervertebral (The Correction and Cure of Deformities of the Vertebral Colum and Their Relation to the Intervertebral Discs). Edward L. Compere and D. Keyes. *Cirugía Ortopédica y Traumatología*, IV, 237, 1936.

The intervertebral disc plays a prominent rôle in the maintenance of the norm function of the vertebral column. Lesions of the vertebral bodies themselves, or of th vertebral discs, or of both, brought about by trauma or disease, are generally followed b deformity of the spine. In the correction of spinal curvatures, either kyphotic or scol otic, one must bear in mind the part played by the intervertebral discs. If some disc have become thin, due to loss of the content of the nucleus pulposus or to displacement these nuclear elements, the correction of the spinal deformity cannot be maintained ad quately without internal fixation by means of some type of spinal fusion.

The authors have described some typical cases of spinal deformity, includin scoliosis, kyphosis due to spinal tuberculosis, compression fractures of the vertebr bodies, and round backs produced by lesions of the vertebral discs. In most of thes patients an improvement of the position was achieved by the use of a plaster cast, includ ing the trunk and the legs, with extenders and hinges, at the level of the most prominen point of the deformity.

In old advanced cases, correction was maintained with the aid of internal fixation,— spinal fusion by excision of the articular surfaces, fracture of the spinous processes, an the use of tibial bone grafts.—*Alberto Inclán, M.D., Havana, Cuba.*

Neoplasms of the Spinal Cord. A Review of Forty-Two Surgical Cases. R Glen Spurling and Frank H. Mayfield. *Journal of the American Medical Associa tion*, CVII, 924, 1936.

The importance of early diagnosis is emphasized. Early root pain is an important symptom when present, but this occurred in only 50 per cent. of the author's series of forty-two cases. Various sensory disturbances were present in a large percentage of the cases. Sensory levels were established in 55 per cent., but clinical examination alone revealed accurate anatomical location in only a small number of the cases. Motor weakness was the first symptom in 31 per cent. of the cases. Sphincteric disturbances were present in 62 per cent. before operation.

Sympathetic changes consist of color, pilomotor, and sweating disturbances. Of these, sweating is the most important, being diminished below the tumor level in the cord. Disturbances of deep and superficial reflexes below the level of the lesion were almost a constant symptom.

Of principal importance in the study of cerebrospinal fluid are the Queckenstedt test for disturbance of cerebrospinal-fluid dynamics, and an increase in the protein content.

Roentgenographic study without contrast medium may demonstrate conclusively bone changes at the site of the tumor. Properly prepared iodized oil may be used with safety, in quantities not exceeding one cubic centimeter, to locate accurately the block caused by the tumor.

From the standpoint of treatment, all except malignant tumors of the vertebrae are considered surgical. Depending on the type and location of the tumor, treatment may consist of total removal, subtotal removal, or decompression. Those tumors that cannot be completely removed are subjected to intensive irradiation after healing of the surgical wound.

The prognosis as regards operative mortality was approximately 7 per cent. Recovery following surgical removal of benign tumors is remarkably good, but it is impossible to predict at operation the degree of functional recovery by the appearance of the cord.—
W. B. Carrell, M.D., Dallas, Texas.

Injuries of the Hand. Clinical Lecture at Kansas City Sessions. Sumner L. Koch. *Journal of the American Medical Association*, CVII, 1044, 1936.

In this article the author mentions and then explains five general principles that should govern the treatment of injuries of the hand:

1. No further harm should be done to the injured tissues by the use of antiseptics, hemostats, or the tourniquet improperly applied.

2. Contaminated tissue should not be left in the injured area; this region should be cleansed thoroughly with soap and water, followed by irrigation with normal saline solution. Badly injured tissue is removed by débridement.

3. As far as possible, the leaving of foreign bodies buried in the tissue should be avoided. This applies to unnecessary ligatures, sutures, kangaroo tendon, metal plates, and other mechanical fixation.

4. Every open wound should be closed as soon as it can be done with safety. The author feels that this can be done in most instances where the infected wound is seen early and is thoroughly cleansed mechanically and followed by exact débridement.

5. Finally, the principle of absolute rest should be applied to injured soft parts just the same as it is applied to fractured bones.—*C. J. Connor, M.D., Dallas, Texas.*

Bone Growth Disturbance Following Hematogenous Acute Osteomyelitis. John C. Wilson and Francis M. McKeever. *Journal of the American Medical Association,* CVII, 1188, 1936.

This paper is based on a statistical study of eighty-five cases of acute osteomyelitis of the long bones and five cases of osteomyelitis of the os calcis.

Of the patients with osteomyelitis of the long bones, 62.35 per cent. had obvious deformity due to disturbance in growth; 21.18 per cent. showed an increase in length, as compared to the well limb, and 21.18 per cent. showed an actual decrease in length. In those cases showing an increase in length in which there was a parallel uninvolved bone, such as in the forearm or in the leg, the uninvolved bone was lengthened correspondingly, so that there was no distortion at the ends and no trouble at the joint. In those showing an actual decrease in length of the involved bones, the parallel bone was not decreased correspondingly, but was at times even increased. In many cases this resulted in a bending of the diseased bone.

Perimetrical hypertrophy is determined by periosteal displacement and is limited by the extent of this displacement. While this perimetrical hypertrophy tends to decrease following healing, it never entirely disappears. It is interesting to note that in bones such as the os calcis, in which the periosteum does not strip easily from the bone, there is no enlargement due to osteomyelitis. Certain deformities are discussed in detail. Coxa valga, resulting from premature closure of the trochanteric epiphysis of the femur, causes an actual lengthening of this bone. Anterior bowing of long bones was noted in five cases and slight degrees of lateral bowing were very frequent. A knock-knee deformity develops either from direct involvement of the epiphysis or from unilateral stimulation either in the tibia or in the femur.

Osteomyelitis of the os calcis is considered separately. It has been found that small abscesses may occur in the body of the bone and recovery may take place without any change in the shape or the consistency of the bone. Since bone grows by accretion rather than at the epiphyseal plate, involvement of the apophysis does not result in shortening or lengthening of the os calcis. When the bone is softened, the muscle pull may alter the shape.

Metatarsal bones and phalanges show great ability to regenerate and to restore normal contour.

The resulting small feet on these involved extremities are difficult to explain, for they occur without prolonged plaster fixation and sometimes they are present when there is only temporary bracing.—*Newton C. Mead, M.D., Dallas, Texas.*

Acute Hematogenous Osteomyelitis. Analysis of Seventy-Five Cases. Robert Crawford Robertson. *Journal of the American Medical Association,* CVII, 1193, 1936.

The essential pathological condition in acute hematogenous osteomyelitis is a bloodstream infection, complicated by a local infection of one or more bones. The clinical

trend has been toward early diagnosis and prompt surgical drainage of an increasingly conservative type. Diaphysectomy and tunnelling have been largely replaced by drilling and removal of a cortical window at the earliest possible moment. Early drainage is advocated on the grounds that the infection occurs within the medulla, usually in the metaphyseal region from which it follows the lines of least resistance, resulting in extensive necrosis and subsequent sequestration.

Analysis of the series disclosed a preponderance of males; most of the patients were between five and fifteen years of age; and there was a relatively small proportion of negroes. Predisposing trauma was not found in 62.6 per cent. of the cases. The distal end of the femur or the proximal end of the tibia was involved in 45.3 per cent. Staphylococcus alone was found in 69.3 per cent. of the wounds and in 24 per cent of the blood cultures. Pain on local bone pressure was present in 63.1 per cent. of the cases not showing sequestration by roentgenographic examination, but in only 4.1 per cent. of the cases that demonstrated sequestration. Fluctuation was found in 31.5 per cent. of the patients, half of whom were under two years of age. The average duration of twenty-two days in the older children was one-third greater, with more deaths, than in children under two years of age.

The type of drainage employed consisted of draining of soft-tissue abscesses, without opening into underlying bone; subperiosteal abscesses were incised, and the underlying cortical window was removed. Postoperative treatment in all cases was by the Orr method, or by a slight modification of this method.

Of the cases without sequestration, 68.4 per cent. were complicated by joint involvement; whereas, of the cases with sequestration, the joint was involved in only 2.3 per cent. Metastatic lesions were most common in cases with sequestration; pathological fracture occurred only twice. Adjacent suppurative arthritis from bone involvement occurred in 24 per cent. of the cases, the hip being involved in 55.5 per cent. Diagnostic aspiration was done routinely.

The mortality rate in the cases with one or more positive blood cultures was 28.6 per cent., death occurring in one week in three-fourths of these cases. Blood cultures in these cases contained staphylococci alone or in combination with streptococci in 75 per cent of the cases.

From this study, the author draws the following conclusions:

1. In children under two years of age, the clinical course of the disease varies widely from that in adults.
2. The American negro is relatively immune to the disease.
3. Acute hematogenous osteomyelitis must be considered when pyrexia and localized pain on bone pressure coexist in the absence of obvious cause.
4. The majority of the best results were obtained by drainage of the bone within one week following onset. The mortality rate was highest in cases in which drainage was instituted within this period.
5. The pathological changes present, while usually directly proportionate to the duration of symptoms, are influenced by many factors.
6. Acute pyogenic suppurative arthritis should be considered to be osteomyelitis of an adjacent bone until proved otherwise.
7. Clinically, joints are more resistant to infection than bone and apparently possess bactericidal properties.—*P. C. Carson, M.D., Dallas, Texas.*

BRODIE'S ABSCESS OF RADIUS, DUE TO TYPHOID. REPORT OF A CASE. William B. Marbury and Henry L. Peckham. *Journal of the American Medical Association*, CVII, 1284, 1936.

Typhoid of the bones is one of the unusual types of inflammatory bone disease. According to Murphy, it occurs in one out of every 233 cases. The bones usually involved, in order of frequency, are: ribs, tibia, vertebrae, femur, clavicle, hand, and radius. The radius is involved only once in 106 cases of osteomyelitis due to typhoid. The abscess may occur in bone from five to fifteen years after infection with typhoid bacillus.

Brodie's abscess is a "bone cavity filled with serum or pus, lined by a fibrous membrane, with surrounding sclerosed bone and a tendency toward obliteration of the adjacent medullary cavity". This abscess usually occurs near the center of the metaphysis, giving rise to symptoms of boring pain referred to the center of the bone and aggravated by use. The symptoms are marked tenderness on pressure or percussion, hydrops of the adjacent joints, and local enlargement of the bone and of the superficial veins; constitutional symptoms are few. Diagnosis is by roentgenogram and by the presence of the symptoms enumerated. Treatment consists of immediate and adequate drainage. The prognosis is good if drainage is adequate.

The authors report the case of a girl, fifteen years of age, with pain in the left forearm for two months, followed by swelling and redness. She had had typhoid at five years of age. Examination revealed a swollen, tender left forearm to the radial side, with redness and elevation of surface temperature. Roentgenographic examination disclosed an oval, slightly irregular, translucent area within the shaft of the radius. The white blood count was 10,100, with 61 per cent. polymorphonuclear leukocytes; the Widal test was positive in dilutions ranging from 1 to 20 to as high as 1 to 320. At operation, ten days after admission, the abscess cavity was opened, and the smear and culture disclosed typhoid bacillus. There were no symptoms after four months.—*P. C. Carson, M.D., Dallas, Texas.*

Fracture of the Neck of the Femur. Evaluation of the Various Methods Advanced for Treatment. Paul B. Magnuson. *Journal of the American Medical Association*, CVII, 1439, 1936.

The anatomy of the femoral neck is described thoroughly and comparisons are made between the weight-bearing lines in young persons and in elderly persons, in whom they may be almost completely absent.

The lack of control of the proximal fragment is often a cause of trouble in these fractures. There is no blood clot formed because the hemorrhage is mixed with synovial fluid and remains fluid. The capsule is shortened because of the distention, and this may interfere with reduction. The blood supply to the neck is often poor.

An important part of the blood supply is from the visceral capsule and it seems logical to believe that injuries tearing this capsule would be slower to heal than others. The exact angle of fracture is, therefore, important and records should be made to show which types produce the most cases of non-union.

The ligaments of the hip joints are relaxed in flexion and tightened in extension. If the fragments are not in immediate contact, extension would further misplace them.

The author believes that one of the important reasons for the fact that extracapsular fractures heal better than intracapsular ones is that the proximal fragment is not entirely out of control in the former.

Anteroposterior roentgenograms are inadequate in determining the approximation of the fragments, and a great many lateral views are also inadequate. Accurate reposition of fragments is necessary to promote union. What may seem to be good position may actually allow contact between a small portion of the fractured surfaces, the rest of which are in contact only with bloody synovial fluid.

In transverse fractures internal rotation tightens the posterior capsule, so that it acts as a soft splint, and the fracture surfaces are brought together. Extension further increases this contact. If distention of the capsule prevents end-to-end contact, these manoeuvers angulate the fragments. If the fracture line is oblique and follows the general direction of the weight-bearing line, internal rotation and extension will push the fragments past each other. Diagrams are presented to show the various angles of fracture and the results obtained by external and internal rotation. Other diagrams show the effect of abduction.

The author describes a fracture near the head in which the head is in valgus position, allowing a good weight-bearing line. This type has never failed to unite in his experience.

As to the choice of methods of treatment, these depend on whether or not reposition

of the fragments can be accomplished and reduction maintained, as well as on the patient's physical and economic circumstances. The Anderson and the Jones splints apparently hold fragments in good position, but actually they may not, for it is impossible to get good lateral roentgenograms once these splints are applied. Their advantage over the Whitman method is in the simplification of the nursing and the ability of the patient to move about.

Internal fixation, blind or open, is discussed. The Smith-Petersen three-flanged nail, the visual reduction of Scuderi and Callahan with Cubbins, the bone graft of Albee and others, and the three-pin method of Moore, all are discussed. In all methods accurate anatomical reposition is necessary for good results.

Another open method which is used by the author is described and advocated for use in fresh fractures. The head is hollowed out in the form of a parabola; the trochanter is cut off obliquely from above downward and outward; and the end of the neck is fitted into the head. The trochanter is reattached below its former location. This results in a good weight-bearing line, and union has always followed this operation in the author's experience. He also uses it in ununited fractures and it has resulted in revascularizing necrosing femoral heads. The method does not necessitate immobilization of the hip, the knee, or the ankle.—*W. B. Carrell, M.D., Dallas, Texas.*

TUBERCULOSIS OF THE HIP IN CHILDREN. Joseph S. Barr. *Journal of the American Medical Association*, CVII, 1517, 1936.

The article is based on 106 consecutive patients admitted with a diagnosis of tuberculosis of the hip. Fifteen per cent. of these diagnoses later proved incorrect, so that the author considers only the ninety definite cases of tuberculosis.

Until 1920, the author's treatment was expectant, ambulatory if possible. Surgical evacuation of abscesses was frequent and was followed by ordinary technique in dressings. Plaster spicas were used for long periods. From 1920 to 1930, heliotherapy, according to the method of Rollier, was used. The patient was placed on a frame in skin traction. No surgery was done. From 1930 until the present time, arthrodesis has been used as the supplementary treatment.

The mortality of tuberculosis of the hip is due to two main causes,—tuberculous meningitis and deep-seated secondary pyogenic infection of the sinuses. Tuberculous meningitis caused 47 per cent. of the deaths. The method of treatment probably does not effect this very much, although arthrodesis might increase the proportion of meningitic deaths. In 40 per cent. of the cases with a fatal outcome, death was due to a deep-seated pyogenic infection of the sinuses. The immediate cause of death was amyloid disease. This is preventable if dressings are carefully done and secondary infection is guarded against. The author allows cold abscesses to rupture spontaneously, but the skin is carefully cleansed and covered with a sterile dressing before rupture takes place. When infection is already present, free dependent drainage is obtained.

The author does not recommend biopsy in early cases, for this often results in an infected sinus. Instead, he believes that aspiration is the best method for obtaining diagnostic material.

Tuberculosis of the hip runs a variable course and the amount of destruction of bone varies. Abscesses were noted in over one-half of the cases. All cases in which there were no complications had reached a quiescent state at the end of four years, most of them after two years. This quiescent state does not represent a cure.

Heliotherapy, as used by Rollier, did not seem to be very effective in the author's cases. These patients showed no more improvement roentgenographically and no better blood picture or clinical appearance than did those not receiving this treatment. The author believes that a moderate amount of sun is good for patients, and that complete rest, local and general, as in pulmonary tuberculosis, is favorable.

Fusion should not be done until the quiescent stage is reached, for in the active stage there is a higher mortality rate and not more than 50 per cent. of the hips are successfully fused. Moreover, even if the fusion is good, the natural process must still be followed.

Attempts to restore active function to hips in which the disease has been arrested are disappointing, for such procedures activate the infection. The disease is more likely to remain arrested in fused hips.

The use of the intra-articular arthrodesis is condemned. The author does not use the massive graft in children, for he feels that it is less likely to fuse and that there is difficulty in maintaining its position while the wound is being closed and the plaster is being applied. The author's technique is briefly as follows:

Through a Smith-Petersen incision, the capsule is cut longitudinally and dissected away. No attempt is made to remove all of the diseased tissue, but visible cartilage is removed from the acetabulum and the femoral head. A cortical flap is raised posteriorly, laterally, and anteriorly from the femoral neck and the greater trochanters. From three to four grafts are then removed from the wing of the ilium and slid down to surround the neck, the lower ends being wedged firmly beneath the flaps at the greater trochanter. The upper ends are still in contact with the cancellous bone of the ilium. A flap of the ilium, just above the acetabulum, is raised and laid across the grafts. No plaster cast is applied. Instead, a firm ace-bandage spica is applied to prevent a hematoma. The child is then placed on a slightly hyperextended Bradford frame with from five to eight pounds of weight on a canvas-stocking extension.

The best position for the fused hip is at from 20 to 25 degrees of flexion, from 0 to 15 degrees of abduction, and from 0 to 5 degrees of external rotation. However, to obtain this final result the author places the limb in full extension and in from 15 to 20 degrees of abduction.

Of twenty-three consecutive cases in which this operation was employed, solid fusion was obtained in 86 per cent. There were three failures, due to destruction of the graft by the tuberculous process. In no case was there shock or sepsis.—*Newton C. Mead, M.D., Dallas, Texas.*

THE OPERATIVE VERSUS THE MANIPULATIVE TREATMENT OF SLIPPED FEMORAL EPIPHYSIS. WITH A DESCRIPTION OF A CURATIVE OPERATION. Samuel Kleinberg and Joseph Buchman. *Journal of the American Medical Association*, CVII, 1545, 1936.

This article discusses the anatomy and the physiology of the slipped epiphysis as compared to the normal epiphysis and from certain deductions suggests reasons why operative treatment is preferable in all types of cases. It also discusses the pathology in the disc.

The conclusion is that, in cases other than the acute cases of slipped epiphysis, reduction and accurate reposition are impossible by manipulation. Even in the acute cases the author states that the end results are poor because of the trauma done to the head of the femur during manipulation and the impossibility of reestablishing a normal circulation to the head through the diseased epiphyseal disc. He, therefore, recommends operative treatment in all cases.

The operative technique consists in the removal of the deformed disc and the nailing together of the accurately repositioned neck and head by the use of an ivory peg, which is introduced through the fovea capitis femoris after the complete removal of the head from the acetabulum, followed by reduction of the head.

The limb is then placed in 30 degrees of abduction and is immobilized in a plaster-of-Paris cast for four weeks.—*C. J. Connor, M.D., Dallas, Texas.*

FRACTURE OF THE NECK OF THE FEMUR IN CHILDREN. Joseph I. Mitchell. *Journal of the American Medical Association*, CVII, 1603, 1936.

Fracture of the neck of the femur is less common in children than in adults past middle age. The method of treatment usually employed in the past for all age groups has been immobilization of the hip in abduction; however, Böhler recommended the use of continuous traction for three months. The types of fractures encountered are: (1) epiphyseal separation; (2) transcervical fracture; (3) cervicotrochanteric fracture. In this series of ten cases, seven were cervicotrochanteric fractures, two were transcervical

fractures, and one was an epiphyseal separation. Four patients were boys and six were girls, ranging in age from four to fifteen years. The cause of fracture in each case was trauma. Bony union occurred promptly in nine cases; good anatomical position, necessary for good function, was found in only three cases, and in four cases the fragments had united in malposition. There was non-union in one case.

Treatment of recent fractures consisted of reduction and immobilization. Whitman's position was used in two cases; in one case a good result was obtained, and in the other two subsequent operations were necessary to correct the coxa vara. In a third case a good result was achieved by the Hoke-Martin apparatus incorporated in plaster. Therefore, all recent fractures of the neck of the femur in children should be treated by continuous traction for eight weeks and the limb should be protected from full weight-bearing for three months, even after the patient is ambulatory. In malunited fractures, the coxa-vara deformity is corrected and the femur lengthened by oblique osteotomy, followed by skeletal traction.—*W. B. Carrell, M.D., Dallas, Texas.*

LATE INFECTION FOLLOWING THE USE OF PINS AND WIRES IN BONES. S. L. Haas. *Journal of the American Medical Association*, CVII, 1607, 1936.

The wide-spread use of pins and wires in obtaining reduction of fractures has not been accompanied by proper recognition of the dangers and sequelae following their use. Many fractures which could be reduced by other means are subjected to unnecessary risks. When a wire is inserted under strict aseptic technique, there is still a portal of entry. There is also an opening which serves as a drain. Granulation forms and acts as a barrier to the infection. For this reason pins and wires should not be allowed to move, for this injures the granulation barrier. After removal of the pin, the soft parts heal more slowly than the bone and this results in a sealed off, non-collapsible tube in the bone, an ideal spot for incubation of latent bacteria. This infrequently happens, but small sinuses and sequestration do occur too frequently.

In a series of seventy cases of leg-lengthening, late infection developed in three, necessitating opening and curettage approximately two years after the pins were removed. This operation was followed by cure of the late infection. The cases were all in children and in each case trauma appeared to be an exciting factor in stirring up the late infection. In all of these cases the cancellous bone of the metaphysis was the site of the infection. A factor favoring late infection may be the force necessary in lengthening operations. When stainless-steel wire is used, there is less local disturbance. At the time of operation the infection was found to be of low grade, the marrow being replaced by fibrous tissue similar to that of osteitis fibrosa.

In extremities which have been treated with pins or wires a subsequent operation may be followed by infection.—*W. B. Carrell, M.D., Dallas, Texas.*

RESULTS OBTAINED BY SUBCUTANEOUS PINNING OF FRACTURES THROUGH NECK OF FEMUR. Avery Rowlette, J. R. Haslem, R. B. Siegert, H. D. Morris, and J. Albert Key. *Journal of the American Medical Association*, CVII, 1610, 1936.

Twenty cubic centimeters of one-per-cent. procaine hydrochloride is injected into the hip joint. Manipulation is then carried out by flexing the thigh to 90 degrees, in a slightly adducted and externally rotated position. Traction is then applied directly upward in the long axis of the femur, while an assistant pulls the upper thigh outward and downward. While traction is maintained, the thigh is circumducted outward and downward and internally rotated. With the heel supported, if it remains in internal rotation, the reduction is satisfactory. Anteroposterior and lateral roentgenograms are made. While the films are being developed, the lateral surface of the thigh below the trochanter is anaesthetized. A stab wound is made in the skin about three inches below the tip of the greater trochanter, and a stainless-steel pin (one-eighth of an inch in diameter, eight inches long, and threaded for a distance of one inch) is inserted down to the femur. The pin is directed in a horizontal plane and upward at an inclination approximating that of the neck of the femur. The pin is drilled into the bone about three inches. Another

roentgenogram is taken and a second pin is inserted, a quarter of an inch above and parallel to the first pin. After this, adjustment of the first pin may be made.

Forty-six cases have been treated by this method in the past eighteen months, only thirty of which have been under careful observation for more than eight months. Of these, six patients have died; one has non-union; three still have pins in and fragments in good position; and thirteen have firm bony union. Among the sixteen cases not yet under observation for eight months, there have been three deaths and two cases of apparent non-union. The failures may be attributed to: (1) poor general condition of the patient; (2) poor reduction; (3) faulty insertion of the pins; (4) failure of the pins to remain in position; and (5) bending of the pins.—*P. C. Carson, M.D., Dallas, Texas.*

THE TREATMENT OF PRIMARY MALIGNANT CHANGES OF THE BONE BY RADICAL RESECTION WITH BONE GRAFT REPLACEMENT. Fred H. Albee. *Journal of the American Medical Association*, CVII, 1693, 1936.

The treatment of malignant growths of bone, especially sarcoma, is extremely unsatisfactory. Metastases develop in spite of the most radical procedures. The author describes a method of eradicating the malignant tumor, but still preserving the usefulness of the extremity. The tumor is resected radically, followed by plastic bone-graft replacement. The author reports thirteen cases in which this method was used.

In three cases in the shoulder region, the upper end of the humerus was replaced by the upper end of the fibula. The diagnoses were osteosarcoma, malignant giant-cell sarcoma, and sclerosing osteogenic sarcoma. The first two patients recovered fully, one of them being alive seventeen years following the operation; the third died of spinal-cord metastases.

Seven cases in the knee region are presented. The diagnoses in these cases were osteogenic sarcoma (two cases), chondrosarcoma (two cases), osteochondrosarcoma, malignant giant-cell sarcoma, and round-cell sarcoma. In one of these cases, that of the highly malignant osteochondrosarcoma, it was possible to save the joint. In each of these cases a cortical graft from the tibia was used.

There were three cases in the tibia, the diagnoses being osteogenic sarcoma, malignant giant-cell sarcoma, and Paget's disease becoming malignant osteogenic sarcoma.

The author concludes that it is possible, in selected cases at least, to preserve a useful extremity in treating bone malignancy. In all of the cases presented, there was no example of local recurrence, although metastases resulting in death occurred in three cases. Dr. Albee believes the method is always indicated in cases of so called benign giant-cell tumors where amputation is indicated. The hematoma which forms about the bone graft may become infected and it is a serious complication. It resulted in the amputation of the extremity in one case in the series.

As far as recurrence is concerned, the method seems to be as safe as amputation.—
Newton C. Mead, M.D., Dallas, Texas.

GIANT CELL BONE TUMOR. FURTHER OBSERVATIONS ON TREATMENT. Carleton B. Peirce and Isadore Lampe. *Journal of the American Medical Association*, CVII, 1867, 1936.

This is a statistical study based on forty cases, twenty-five of which were diagnosed at autopsy and the rest by clinical and roentgenographic findings. The cases are divided into five groups, a separate table being presented for each group. The groups are as follows: (1) untreated cases; (2) those treated by preoperative x-ray, surgery, and postoperative x-ray; (3) those treated by surgery and postoperative x-ray; (4) those treated by surgery only; and (5) those treated by radiation only.

The authors' conclusions are that the lack of uniformity in the treatment of giant-cell tumors by combined surgery and x-ray defeats any attempt at satisfactory comparative analysis.

Preoperative radiation has been permitted little opportunity for effect and has been urged on radiologists largely in those cases which are unfavorable at the outset.

Secondary infection, subsequent to primary surgical intervention or biopsy, offers definite obstruction to improvement by irradiation.

Adequate curettage has induced good functional results in anatomically accessible areas.

Either adequate treatment with x-rays or adequate surgical intervention offers as much as a combination of the two.

Conservative treatment with x-rays will afford symptomatic relief and induce anatomical repair.—*Newton C. Mead, M.D. Dallas, Texas.*

Tuberculosis of the Spine and Scoliosis. An Improved Technic for Arthrodesis of the Vertebral Joints. Charles S. Young. *Journal of the American Medical Association*, CVII, 2035, 1936.

Arthrodesis of the spinal column in scoliosis and tuberculosis of the spine has presented the problem, the solution of which calls for an operation that will apply to all regions of the spinal column, that will be reasonably certain of arthrodesis without development of pseudarthroses, and that will have a minimum amount of surgical shock. The widely used operations are those of Hibbs and Albee. The Hibbs operation is intra-articular, but it has the disadvantage of causing undue trauma to the central nervous system. Also, in scoliosis, with severe rotation, it is not technically possible to remove cartilage from the deep side. The Albee operation is extra-articular and presents a difficulty due to lack of uniformity in the spinous processes. The sacral processes are too rudimentary, and the thoracic spinous processes, when bisected, present very narrow and thin surfaces for the reception of bone transplant.

The author describes an operation which he has been using in tuberculous diseases of the spinal column. The skin and superficial fascia are reflected until the supraspinous ligaments are exposed and divided in their midline longitudinally and are reflected laterally with the muscles, which are separated subperiosteally from the spinous processes and the laminae. Care must be taken to remove every particle of these ligaments from the laminae and the spinous processes. Two flexible bone grafts are next obtained from the tibia. The graft is fitted so that its raw surface is in perfect contact with each lamina and base of the spinous process. The grafts are held in position by suturing the periosteum to the spinous process. Postoperative immobilization is maintained by means of a plaster-of-Paris body jacket. In young children, the shells are made and dried before operation. The older children are placed on Bradford frames, unless severe kyphosis is present, until after the sutures have been removed; then plaster-of-Paris jackets are applied. The patient should remain recumbent for from three to six months. On removal of the plaster-of-Paris jacket, a back brace is worn for from six to nine months.

In the thoracic region, in cases of severe kyphosis, the spinous processes may be excised to decrease the deformity.

In treating scoliosis, the procedure is the same except that in cases of marked rotation one side may be done and a wide graft used. Postoperative treatment consists of head and pelvic traction or a turnbuckle jacket for from four to six months.—*W. B. Carrell, M.D., Dallas, Texas.*

Club-Foot and Its Treatment. A. Wilfrid Adams. *The Medical Press and Circular*, CXCIII, 348, 1936.

The author stresses the necessity of seeing and treating these cases early to get the maximum correction without stiffness. Inversion, especially of the heel, adduction, and cavus are the main elements of the deformity. Correction should be attempted as soon after birth as can conveniently be arranged.

The following method of treatment will give the potential cripple a foot of well-nigh perfect form with full function.

The infant is anaesthetized and firm pressure is made over the heel to correct the heel varus. Next, the forefoot adduction is corrected by manual pressure and plaster is applied. The author stresses the importance of extending the plaster to the tip of the

toes; the toe opening should be narrow to prevent overlapping of the digits, due to the inward pressure of the cast.

In two weeks the plaster is removed and the same procedure is repeated, until in about eight weeks the foot remains in its overcorrected position.

Correction of the equinus is then begun by a manipulative procedure every three weeks until the dorsum of the foot touches the front of the tibia.

The completion of this series of manipulative procedures concludes the first stage of treatment.

The preservation of this correction is maintained by the use of a light wooden sole plate fixed to the foot and leg by elastoplast straps.

After twelve months, the retentive appliance is removed and walking is permitted. Strapping may be reapplied if relapse threatens.

In late stages, manipulative correction with transplantation of the tibialis anterior to the fifth metatarsal is a good procedure, or a modified Steindler operation may be used. In old cases or in adults, the writer uses osteotomy through the forefoot and tarsal bones, or Syme's amputation.—*Herbert E. Hipps, M.D., Marlin, Texas.*

THE PROBLEM OF THE CHRONIC ARTHRITIC. P. F. Ashton. *The Medical Press and Circular*, CXCIII, 485, 1936.

There is no excuse for the pathetic case of the hopelessly crippled arthritic if the patient is seen early enough and a rational method of treatment is instituted.

Geography, climate, and diet play no part in the etiology of arthritis except in the cases of undernourished and very obese individuals. With the two exceptions just mentioned, arthritics may eat what they like.

Arthritis may be broadly divided into two distinct groups: polyarthritis and osteo-arthritis.

There are two pathognomonic symptoms in polyarthritis: (1) stiffness in the joints on waking in the morning or after a rest period during the day; (2) the patient may complain of dropping things if the early arthritic process is in the upper extremity, or of his knees giving away, if in the lower extremity. These symptoms appear before joint soreness, swelling, etc. occur.

There are three main varieties of polyarthritis, but the symptoms described are common to all types. These varieties are grouped according to age and are as follows: (1) adult, (2) menopausal, and (3) senile.

In the treatment of polyarthritis rest is by far the prime essential for a possible cure of this disease. This is very important, as most patients have the idea that rest makes the joints stiff, whereas the converse is true. Massage, carefully given, is of value. Medication may consist of salicylates, or of thyroid extract if the patient is obese, and in some cases acetylcholine is prescribed because of its selective action on the sympathetic nervous system and its subsequent warming up of cold extremities.

Osteo-arthritis is nearly always traumatic in origin and is simply a senile decadence or wearing out of the involved joints. The symptoms vary, but frequently the pain is referred down the arm or leg below the joint; nerve pain from the spine is also encountered.

Treatment is rest of the involved joint, and again this is of prime importance. Physical therapy is of definite value here. Diathermy through the involved joint gives considerable and quick relief from pain, but it should not be given daily. Two or three times per week is better to allow for full tissue response after each treatment. Massage is of no value in these cases.—*Herbert E. Hipps, M.D., Marlin, Texas.*

BEITRÄGE ZUR KLINIK UND THERAPIE UNSPEZIFISCHER WIRBELERKRANKUNGEN (Some Clinical and Therapeutic Aspects of Non-Specific Affections of the Vertebrae). F. Raszeja. *Mitteilungen aus den Grenzgebieten der Medizin und Chirurgie*, XLIV, 401, 1936.

The author divides the non-specific affections of the vertebrae into three categories:

1. The first group comprises the acute and subacute suppurative inflammatory conditions of the vertebrae (spondylitis staphylomycotica and streptomycotica). The treatment is purely surgical and must ensue as soon as the diagnosis is established. Abscesses are incised; aspirations and irrigations are insufficient and are even injurious. The incision should be extended to the site of infection to permit curettage of the affected portions of bone and to remove any sequestra which form for the most part in the vertebral arches. When the vertebral bodies are affected, costotransversectomy and lumbovertebrotomy are to be considered. Paralyses definitely indicate laminectomy. Plaster-bed immobilization guards against gibbus formation. A plaster or steel corset must be worn during convalescence.

2. In the second group, the author includes chronic vertebral osteomyelitis, infectious spondylitis, and the more infrequent vertebral affections which occur in the course of various infectious diseases (spondylitis typhosa, paratyphosa B). Four cases are discussed in detail. The treatment of the disease forms belonging to this group is fundamentally surgical, although too radical a procedure is not indicated and is limited in the first place to the incision of abscesses. There is no indication for the invasion of the site of the infection, which is usually found in the vertebral body. Paralyses present no indication for laminectomy here; they usually regress spontaneously, and more rapidly following x-ray therapy. In addition to x-ray therapy, which seems to be applied more frequently than before in cases of paraesthesia and root symptoms, blood transfusion has been used with success; convalescent survivors of acute osteomyelitis are preferred as donors. Results obtained with polyvalent vaccination or autovaccination were not striking.

3. In the third group, the treatment of spondylarthritis ankylopoetica is described, which the author regards as a rheumatic or rheumatic-infectious affection, and he distinguishes three clinical stages. Rather large doses of pyramidon are administered and light thermotherapy is chosen in the initial stage. In the fully developed stage, stimulation therapy and hyperthermia of the tissues (diathermy, mud packs, and baths) come into consideration. Hydrotherapy, massage, and gymnastic exercises are indicated during the painless-interval stage. Immobilization in plaster beds or corsets is injurious. Movement is necessary in all stages. Painful intercostal neuralgia is alleviated by intercostal anaesthesia and with greater success by paravertebral anaesthesia according to Laewen. Rabl's acidification with ammonium chloride has not been successful. Parathyroidectomy was attempted in three cases; in two cases, the results were fairly good. The author regards this operation to be indicated in all cases of high hypercalcaemia and in younger individuals in whom the condition has not resulted in any marked bone changes.—*O. Theodore Roberg, Jr., M.D., Chicago, Illinois.*

MENISCUSGANGLIEN UND UNFALL (Cysts of the Semilunar Cartilage and Trauma). H. W. Ott. *Monatsschrift für Unfallheilkunde und Versicherungsmedizin*, XLIII, 618, 1936.

Cysts of the semilunar cartilage are probably far more prevalent than the previous reports would indicate. Failure to recognize them is responsible for the small numbers reported in the literature. In most of the cases hitherto described, trauma was supposed to be the important etiological factor. Ott, however, is of the belief that there is an anlage which is responsible for this condition. He reports five cases.—*I. William Nachlas, M.D., Baltimore, Maryland.*

TRAITEMENT DE CERTAINES FRACTURES ARTICULAIRES (Treatment of Certain Articular Fractures). René Leriche et Fritz Froehlich. *La Presse Médicale*, XLIV, 1666, 1936.

In certain types of articular fractures, where there is no displacement, or where exact reduction is not necessary, periarticular infiltration of the ligaments and intra-articular injections of novocain, to block the vasomotor phenomena, which lead to second-

ary arthritis, are indicated. The possibility of resuming active motion immediately permits cure in the minimum of time, with the maximum of function.

The authors report a case of comminuted fracture of the elbow, another of fracture of the head of the radius, and a third of transverse fracture of the patella, in which daily injections of novocain were given. As long as there was pain which prevented active mobilization, twenty cubic centimeters of 1-per-cent. novocain was injected into the periarticular ligaments daily, until a free range of painless motion was possible.

The results in these cases were extremely satisfactory. In only one case was the disability prolonged to three months.—*Henry Milch, M.D., New York, N. Y.*

L'HÉMATOME DU QUADRICEPS CRURAL (Hematoma of the Femoral Quadriceps). Paul Durand. *La Presse Médicale*, XLIV, 1736, 1936.

A teamster was kicked on the anterior surface of the thigh and thrown to the ground. Examination disclosed tenderness, inability to walk, no fluctuation, and inability to flex the leg upon the thigh. This loss of flexion is particularly important, since it indicates the characteristic of muscle injuries,—resistance to lengthening of the injured muscle fibers.

The author advised treatment by aspiration and subsequent injection of two cubic centimeters of Calot's solution.—*Henry Milch, M.D., New York, N. Y.*

QUELLE INFLUENCE UNE THROMBOSE LIMITÉE EXERCE-T-ELLE SUR LES ARTÈRES EN AVAL? (What Influence Does a Limited Thrombosis Exert on the Peripheral Portions of the Artery?) R. Fontaine, E. Lucinesco, R. Schattner, et A. Oswald. *La Presse Médicale*, XLIV, 1860, 1936.

As a result of studies of the effects of arteriectomy and of limited thrombosis of an artery on the peripheral portions of the artery, the authors came to the conclusion that the arteriectomized animals showed a richer peripheral vascularization, with fewer cases of trophic disturbance, ulceration, or gangrene than did those in whom segmental thrombosis had been accomplished. In studying nineteen experimental animals they noted that the arteriectomized animals showed absence of the secondary arteritis, which was associated with thrombosis. This is in accord with the findings of Leriche and is probably to be attributed to the vasodilatation which follows arteriectomy. This is consequently in accord with Leriche, who suggests arteriectomy in cases of limited thrombosis.—*Henry Milch, M.D., New York, N. Y.*

POLYRADICULON NÉVRITES (Polyradicular Neuritis). G. de Morsier et J. Steinmann. *La Presse Médicale*, XLIV, 1890, 1936.

The authors report two cases of the syndrome described by Guillain, Barré, and Strohl in 1916. This condition is characterized by paraesthesia, muscle weakness, loss of tendon reflex with persistence of the superficial reflexes, hyposensitiveness of the lower extremities, loss of sphincteric control, and most particularly a hyperalbuminosis, without pleocytosis. One of these patients recovered and the other died. In this latter case autopsy disclosed no evidence of any spinal-cord lesion, but there was a marked perivascular infiltration about the nerves, as well as definite evidence of inflammation of the sheath of Schwann. In the milder cases, which involve the lumbar nerves, recovery occurs. Where the lesion is situated higher and involves the cranial nerves, as in the second case reported, death may occur.—*Henry Milch, M.D., New York, N. Y.*

TRAITEMENT AMBULATOIRE DES FRACTURES DU CALCANÉUM (Ambulatory Treatment of Fractures of the Calcaneum). Philippe Graffin. *La Presse Médicale*, XLV, 61, Jan. 13, 1937.

Six cases of fracture of the os calcis are reported in which immediate ambulatory treatment was undertaken. The technique is as follows. Stockinet is drawn over the leg from the toes to below the tibial condyle. A pad of cotton, four centimeters thick, is now placed over the heel, extending from the upper surface of the ankle joint posteriorly

along the back of the heel to its plantar surface as far forward as the calcaneocuboid joint. Another piece of stockinet is placed over this to hold the cotton in place, and plaster-of-Paris is applied from the toes to below the knee. The plaster is made particularly strong, to permit walking, and is flattened by means of a board. As the patient walks, the os calcis tends to be pushed down into the space between the stockinet and the plaster.

Of the six cases, five showed excellent results within a period of two months, regardless of the nature of the fracture. The author concludes that in this way the severe symptoms of post-traumatic arthritis and the long disability may be avoided.—*Henry Milch, M.D., New York, N. Y.*

FRACTURES IN THE REGION OF THE SHOULDER-JOINT. R. Watson Jones. *Proceedings of the Royal Society of Medicine*, XXIX, Section of Orthopaedics, 20, 1936.

The author reviews 571 injuries to the upper end of the humerus treated in the fracture clinics of the Liverpool Royal Infirmary during the five-year period from 1929 to 1934. He discusses the treatment which these cases received according to the following classification:

1. Fracture of the greater tuberosity;
2. Dislocation of the shoulder joint;
3. Fracture of the neck of the humerus;
4. Fracture-dislocation of the shoulder.

1. If the bone is fractured by direct contusion, there is little displacement. If the fracture is associated with great traction by the supraspinatus, there is usually displacement. Recent cases never need operative treatment.

2. Myositis ossificans is encouraged if passive movement is done, whereas if only active motion is allowed there is little evidence of myositis ossificans. The incidence of nerve injury is great,—thirty-four nerve injuries in 231 cases.

3. There are three types of fracture: contusion crack without displacement, adduction fracture, and abduction fracture. The adduction fracture is usually impacted. The abduction fracture is or is not impacted.

4. This type may be impacted or unimpacted. Reduction may be possible without incision. In certain cases, even with reduction of the head, an aseptic necrosis may result and lead at a later date to operative treatment because of a painful shoulder.

This review of an important group of shoulder injuries illustrates the careful observation and sound conclusions of Mr. Watson Jones.—*C. L. Scudder, M.D., Boston, Massachusetts.*

DERANGEMENTS OF THE SEMILUNAR CARTILAGES OF THE KNEE. A CLINICAL AND EXPERIMENTAL STUDY. A. R. Shands, Jr., Jay L. Hutchison, and Louis Ziv. *Southern Medical Journal*, XXIX, 1045, Nov. 1936.

This is a study of forty-eight cases with experimental data on the regenerative changes after removal of semilunar cartilages in eleven dogs. Etiology, diagnosis, and treatment are discussed. Patients with acute cases are treated first with physiotherapy. As the patient becomes ambulatory on crutches, the knee is protected by a cotton-board splint and elastic bandage dressing. If the patient is an athlete, a knee-cage brace, made of leather and steel, with joint motion is applied before he returns to active games. If slipping of the cartilage persists, operative removal is advised. Symptoms, operative findings, and postoperative results are charted. Experimental data on dogs showed that there was a definite regeneration after removal of the cartilages.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

ACUTE OSTEOMYELITIS IN CHILDHOOD. DIAGNOSIS AND TREATMENT. H. Earle Conwell and John D. Sherrill. *Southern Medical Journal*, XXX, 171, Feb. 1937.

Emphasis is laid upon the early diagnosis and treatment of this condition. The authors divide the cases into two groups—infants under two years and older children—as

the course of the disease is different. Early and adequate drainage is advocated. Very sick and dehydrated patients are the only cases in which delay is justifiable.

Incision is made over the area of exquisite tenderness. The periosteum is always incised, and holes are drilled into the medulla. When pus is encountered, a window is made into the medullary cavity, as drill holes will fill up with granulations and drainage will be inadequate. Drainage is by rubber tubes and gauze packs. All bleeding points are thoroughly ligated. Transfusions are valuable. Deep x-ray therapy has been used in convalescent cases in which a large granulating area is slow in healing. This hastens the healing. In no cases, however, should the deep therapy be expected to be of benefit to the bone infection.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

THE BONE CHANGES IN SICKLE CELL ANEMIA. L. W. Diggs, E. N. Pulliam, and J. C. King. *Southern Medical Journal*, XXX, 249, March 1937.

This paper summarizes the known facts concerning the pathology and the roentgenographic appearance of bones in sickle-cell anaemia. It is well illustrated and gives charts showing the location of the bone changes in the different bones. The skull picture is very marked and characteristic. The bone marrow is primarily involved. Both osteoporosis and sclerosis are noted.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

AN ARTHROPLASTIC OPERATION FOR CONGENITAL DISLOCATION OF THE HIP—A TWO STAGE PROCEDURE. Paul C. Colonna. *Surgery, Gynecology and Obstetrics,* LXIII, 777, Dec. 1936.

The writer reports six cases of congenital dislocation of the hip, treated by the method which he described in *The Journal of Bone and Joint Surgery* for January 1932. The pathological anatomy is described and the author stresses the "hour-glass" appearance of the capsule and contractures of the soft tissues as barriers to reduction.

The first stage of the procedure consists of subcutaneous tenotomy of the adductors, followed by traction to bring the femoral head opposite the acetabulum. The second stage is the open surgical reduction in which the elongated portion of the capsule is employed as a membrane about the femoral head, which is placed in a reamed-out acetabulum without tension. Postoperative traction is used in the older cases for two weeks, followed by a plaster spica. Weight-bearing is allowed after three months.

The cases presented are adequate to show the efficacy of the method. The article is well illustrated with line drawings of the operative procedure and serial roentgenograms.—*Richard McGovney, M.D., Santa Barbara, California.*

FRACTURES OF THE OS CALCIS. Melvin S. Henderson. *Surgery, Gynecology and Obstetrics,* LXIII, 782, Dec. 1936.

The writer presents statistics and conclusions based on a series of fifty-four cases seen at The Mayo Clinic. Twenty-two of the cases were fresh fractures and thirty-two were old fractures. There were only two females in the entire group. Function only was considered in tabulation of the results.

Most of the fresh fractures were treated by molding and plaster. The use of the Kirschner wire and the Gillette apparatus was recommended. Of these twenty-two patients, seven had excellent results, returning to work in from three to four months; six had good results, working with some pain; two had only fair results after a year; and one claimed complete disability after two years. The results were not known in six cases.

In two-thirds of the cases of old fractures the cause of the disability was astragalocalcaneal traumatic arthritis. Triple arthrodesis was advised in fourteen cases, but was accepted by only three patients.

The period of disability was definitely longer in industrial compensation cases. Where a job was waiting the disability was shorter. The reader is left with the thought that although the disability is considerable at first it gradually lessens over a period of years.—*Richard McGovney, M.D., Santa Barbara, California.*

CRUCIATE LIGAMENT INJURIES CAUSED BY COMPLETE AND INCOMPLETE DISLOCATIONS. EARLY AND LATE PATHOLOGY, SYMPTOMS, AND A METHOD OF REPAIR. William R. Cubbins, James J. Callahan, and Carlo S. Scuderi. *Surgery, Gynecology and Obstetrics*, LXIV, 218, Feb. 1937.

The writers present in all sixteen cases of cruciate-ligament injuries, ten of which were double. There were nine patients with complete dislocation of the knee joint. Five of the patients seen early obtained good functional knees, following reduction and immobilization for four months. The diagnosis should be made by clinical examination, preferably under anaesthesia, as roentgenograms are not informative enough. In the operated cases no traces of cruciate ligaments were found three months or more after the injury. The menisci were not damaged.

A method of reconstruction of the cruciate ligaments is described. A thirteen-inch lateral incision is made, beginning ten inches above the joint; a strip of fascia lata, one inch wide, is dissected down to the lateral femoral condyle; a similar posterior strip is dissected down to the tibial head. The knee joint is then opened by a medial patellar incision. Holes are now drilled horizontally through the lateral femoral condyle, obliquely downward and inward through the medial femoral condyle, and obliquely upward and inward through the medial tibial head. The posterior fascial strip is carried around the fibular head, upward through the fascia and posterior joint capsule, and drawn through the medial femoral condyle, forming the posterior ligament. The anterior ligament is formed by drawing the anterior strip of fascia through the lateral femoral condyle and down through the medial tibial condyle. Both ends are sutured subperiosteally. A plaster is applied with from 25 to 35 degrees of flexion. One full year is required for complete recovery. There were no stiff joints in the authors' series. Too long a period of immobilization is less to be feared than too short a period. The article is well illustrated.—*Richard McGoracy, M.D., Santa Barbara, California.*

ZUR VERLETZUNGSBEHANDLUNG (Some Aspects of Traumatic Surgery). *Wiener klinische Wochenschrift*, L, 55, Jan. 15, 1937.

Prof. Wittek emphasizes the early and proper treatment of lacerations of the knee joint, and presents a method which he employs to promote ankylosis of pseudarthroses following fractures of the femur which have resisted other forms of treatment. It embodies the principle of functional burdening whereby abnormal mobility in the sense of lateral or longitudinal displacement is to be safely avoided. The method consists in drilling two extension wires, one above the femoral condyles and the other in a sagittal direction, through the greater trochanter. These are placed in tension stirrups and the pelvis and the affected thigh with its wires are enveloped by a plaster cast. Further treatment is ambulant. This method also provides early ambulatory treatment for fresh fractures of the femur. Wittek states that he subsequently learned that a similar method was in use in the United States.

In sixty-two cases of knee lacerations (thirty-nine with open joint injuries) reaching the Clinic within forty-eight hours following injury, surgical treatment resulted in fifty-nine complete cures and three stiff joints. Twenty-eight patients, entering later than forty-eight hours after injury, with some inflammatory changes already present, recovered with little loss of knee function. Of thirteen patients previously treated and brought in with severe infections, four died, one required amputation, two became ankylosed, and six recovered with more or less limitation of motion. Of forty-five patients who were sent in for supplementary care, pain and limitation of motion resulted in seventeen; three presented only amputation stumps; eighteen, ankyloses; five, contractures; and two, previously undiagnosed division of the ligamentum patellae.

Such statistics are to be improved only by adherence to the following rigid principles of treatment: (1) immediate excision of all tissue suspected of being infected; (2) primary closure of the joint capsule and reestablishment of joint function; (3) prophylactic filling of the joint with an antiseptic; and (4) immobilization.—*O. Theodore Roberg, Jr., M.D., Chicago, Illinois.*

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The Contribution of Orthopaedic Surgery to the Lister Antiseptic Method *

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A knowledge of the history of orthopaedic surgery should form the background of every clinical procedure and of every contribution to the literature of our specialty. Only in the light of historical perspective is it possible to formulate those fundamental assumptions which constitute the principles with which all methods and techniques in orthopaedic practice must comply.

We live in what has been called the "gadget age" and in a keenly competitive professional environment. In the desire to produce something different, procedures are often proposed which are clever in conception, but which fail to comply with rules that are fundamental. Every orthopaedic surgeon should be "good at gadgets", but he should not spend too much time, or too much ink and paper, in trying to persuade the rest of us to use his gadgets for things we can do better with our own. Moreover, in the selection of special technical methods of our own or others, their complete compliance with principles must always be the primary requisite. It is the failure to evaluate methods and techniques in the light of principles that leads to errors in the choice of apparatus and of operative procedures.

One of the simplest illustrations of disregard for a principle is that we often see unsatisfactory results in the treatment of club-foot because of failure to overcorrect the deformity. To correct, merely, is to neglect the fundamental principle that the establishment of a full normal range of motion is an essential of treatment. The maintenance of overcorrection by operation, splints, and shoes, until all the parts are soundly healed, involves compliance with a principle which may not be disregarded if good results are to be obtained. The details of technique may be different and interesting, but the fundamentals to be kept constantly in mind must always be the same.

* Presented at the Annual Meeting of the American Orthopaedic Association, Lincoln, Nebraska, June 3, 1937.

Hippocrates taught that "it is the first duty of the surgeon to do his patient no harm" and that "we should assist nature and not get in nature's way". It is the restoration of parts to normal relationship, the relief of deformity, the provision of surgical and mechanical devices for affording rest, and the alleviation and cure of disability that must characterize the work of the orthopaedic surgeon.

No recent phenomenon in surgical practice has emphasized so much the importance of adherence to fundamentals as our experience with the Lister antiseptic method. Lister's teaching gave us a new principle,—the exclusion of known and harmful infection from wounds. In the efforts to apply and improve the Lister method a large majority of surgeons have gone astray.

At a meeting of the British Medical Association in Dublin in 1867, Prof. Lister promulgated his new doctrine.[10] In some respects, it now appears to have been unfortunate that, in carrying out his technique, Lister employed carbolic acid and called his method the antiseptic system. Most of his followers have endeavored, unsuccessfully, to employ chemical antiseptics as a means of combating infection in wounds instead of recognizing that it was the principle of exclusion of infection that lay at the bottom of the Lister revolution in surgery.

At about the same time as Lister's original work, Hugh Owen Thomas, of Liverpool, was teaching a method of control of inflammation and infection which rested upon a different principle. He stressed the ability of the patient to recover from various bone and joint diseases under circumstances and conditions designed to favor only the most efficient employment of the patient's own defenses.

Regarding the Lister method, Thomas [18] said: "For some years previous to the introduction of the antiseptic method, I practised the open method and was well satisfied with the results obtained, but on the publication by Professor Lister of his successes, I at once commenced the practice of antiseptic surgery [this was as first taught by Lister, and included the carbolic spray] and continued to practise it for three years, with the result of being perfectly satisfied that its merits have not been over-stated nor the trouble necessary for carrying out the details exaggerated. I returned, however, at the end of that time to the open method, and have since laboured to improve it, so much so that I am emboldened to assert that the open method, in results and successes, is equal, if not superior, to anything to which antiseptic treatment has yet attained."

Thomas was quick to see that the Lister method which tampered with wounds and disturbed the patient violated the principle of repair by rest which was so significant to him. Thomas understood, as few before or since have understood, the importance of providing true physiological rest for the patient. He pointed out on many occasions the tendency of the patient toward spontaneous repair and said that nature always has a mode of operation if the surgeon can only understand and employ it. He recognized the teachings of Hilton, the great apostle of rest, but said

that Hilton's efforts at immobilization were inadequate because he did not know how to apply splints or apparatus without compression or constriction of the affected part.

That Thomas had a broad view of his own method is indicated by his statement[19]: "Men admired my splints as if I were a blacksmith, but the principles on which they were framed they never could see"; and, further, that of Sir Arthur Keith [7] in his sketch of Thomas: "We see that he carried out, just as he proposed it should be carried out in the treatment of intestinal obstruction, and as it never had been carried out before in cases of diseased hip-joint, a system of 'enforced, uninterrupted and prolonged rest'. 'A man', he said, 'who understands my principles, will do better with a bandage and broomstick than another can do with an instrument-maker's arsenal.'"

The open method to which Thomas refers was that devised by Bartscher and Vezin [2], who published a description of it in 1856. This method appeared to be opposed to the antiseptic method, but actually, when carried out under conditions of protection to the wound, was one which was sure to appeal to a man with Thomas' ideas in regard to the value of natural resources in the cure of disease.

In the open method, the wound surfaces or the diseased areas were bathed with the antiseptic and antitoxic solutions manufactured by the patient himself. This conformed to nature's design to rid him of undesirable organisms or toxins and to promote healing. Such a program implied the protection of the patient against washes, chemical antiseptics, frequent dressings, and other disturbances to which Thomas was so sincerely and vigorously opposed. It provided also for the escape of blood clot and other materials likely to remain inside the wound and to be subject to fermentation.

Due to a misunderstanding of the Lister idea, constant or intermittent irrigation methods have been encouraged. This plan goes back really to the time of Langenbeck [9] in 1839. To such disturbing methods orthopaedic surgeons, especially, should always take exception as did Thomas, on account of the damage to the wound and the wound area and the interference with suitable splinting and other devices for obtaining rest and protection for the injured part and the patient.

Orthopaedic surgeons should recognize that Thomas' success without the use of the carbolic spray and without the use of wet antiseptic dressings was partly due to the fact that he did actually protect the patient to some extent against invasion by organisms. This, however, he considered to be of secondary importance to the use of well-fitting and efficient apparatus for the care of the patient in correct position and at rest.

It is important to remember that there has always been a difference of opinion regarding wound treatment. Magati [13], Belloste [3], Paré [14], Hunter [6], Hilton [5], and Thomas [17], all argued for protection and infrequent dressings, but they lacked the knowledge of infection that came with the Lister revolution in surgery.

It seems a pity that the methods of Thomas and Lister could not have been combined at the very beginning. The inability of surgeons generally, and of surgery as a specialty, to realize the full benefits of the Lister method has been due to the failure to combine protection and rest with the Lister antiseptic method.

At the end of the War, in 1919, one misguided follower of Lister wrote that in a suppurating wound "*the principles of treatment* consist in a removal of the discharge by free incision, by large drainage tubes, by frequent irrigation with antiseptic lotions, and by the use of baths, fomentations, and compresses". It seems very sad to have these called "principles". Every technical item suggested involves a violation of principles as most of us understand them.

The degree of error into which we have been led in this direction is indicated by the following quotation from one of our standard surgical works [15] in 1918:

"Probably one of the most striking examples of the treatment of infected wounds which has resulted from this present war is that which has been evolved by Carrel of the Rockefeller Institute, and, at present, in charge of a hospital at Compiégne. In the period before this war commenced, and even in the earlier days of the conflict, the aseptic treatment of wounds was advocated. This soon proved inadequate, and various other ideas of treatment, some more or less theoretical, were advanced. It remained, however, for Carrel to apply in a scientific manner the treatment which had been advocated sixty years previously by Lister, namely, the treatment of infection by antisepsis."

That Lister did, in fact, tend in this direction is indicated by the following [12]: "And whenever discharge is considerable, it is essential that the dressing be of a kind which will not permit the development of septic organisms in it, although it be saturated throughout; and this can, I believe, only be attained by the use of chemical antiseptic substances.

"I have for some time past employed for this purpose a combination of the two cyanides of zinc and mercury, which appears to fulfil the requisite conditions of antiseptic efficacy and due storage of the agent in spite of free discharge, together with absence of irritating properties. Having already published on this subject, I will not detain the members of the Congress with details regarding it, further than to say that since the date of that publication Professor Dunstan, of the London Pharmaceutical Society, has devised means by which the substance can be prepared in a perfectly definite manner, and containing twice as great a percentage of the cyanide of mercury as that which we have hitherto used; and, as I have ascertained that the cyanide of mercury is the more important ingredient antiseptically, and also that its larger amount in Dunstan's material does not make the salt irritating, we may fairly regard the new preparation as an improvement."

The antiseptics suggested by Penhallow were iodine, carbolic acid, peroxide of hydrogen, and common salt. Thousands of others have been

tried in the same way,—even maggot extract! Such procedures, in disregard of principles, led to the alleged failure of the Lister antiseptic method during the War. In such treatment the employment of efficient splints and casts has always been impossible and the control of fractures and fracture fragments is entirely out of the question. Neither can anyone adhere strictly to the Thomas idea of rest in the treatment of compound fractures if weight and pulley traction are employed. The use of Thomas splints with supplementary suspension in Balkan frames, weights, and pulleys, and ice tongs and pins with elastic traction, constitutes a complete departure from the teachings of Thomas regarding requirements for rest. With Thomas' well-fitting hip and knee splints no such adjuncts were permitted or required. With the general adoption of the idea that frequent dressing of wounds is unnecessary, and that exclusion of infection is the point of real surgical importance in the dressing, provision for easy access to the wound and frequent disturbance of the patient becomes not only unnecessary but prejudicial in every way.

In fairness to Lister himself, it must be acknowledged that he recognized that there was a drift away from the principle which he had enunciated originally. This is apparent in an address which he gave in 1889[11]. He was recommending the use of the double salt of cyanide of zinc and mercury as having claim to favor as a germicide and for its inhibitory effect upon the growth of organisms. His final words must be given the most careful consideration: "I believe I happened to be the first to direct attention to the antiseptic agency of living structures, and there is, perhaps, no one who attaches greater importance to it than I do. Without it, surgery in former days would have been absolutely impossible. Still, I know too well from experience that it cannot always be trusted, and that the use of antiseptic adjuvants is in the highest degree important. . . ."

There has been a disposition since Lister's time to carry into the operating room and into the hospital wards methods of antiseptic dressing and treatment which are of obvious disadvantage and discomfort to the patient. Both laboratory workers and surgeons have failed to realize that germicides and so-called antiseptic methods developed in the laboratory must be adjusted to the patient's general welfare and to his ability to defend himself against the surgeon as well as against infection.

There are those who say that there is no disagreement as to the importance and the propriety of rest in the treatment of fractures or other injured or inflamed extremities. While rest is mentioned by nearly all writers on this subject, it is rarely employed in the sense that Thomas intended it should be. If one considers this attitude in the light of our introduction, it may be seen that Lister's original teaching did not involve any contradiction of the principle of rest. However, the so-called Listerian techniques—irrigation, tube drainage, chemical antiseptic dressings in wounds, and the like—are all, in fact, departures from or corruptions of the Lister method. In so far as they damage the wound surface or disturb the patient they violate important surgical principles, for the appreciation

of at least one of which (the protection of the wound surface against infection and damage by chemicals) Lister, himself, was chiefly responsible.

It is usual for writers on surgical methods of the present day to advocate rest for compound fractures, but they provide for the reduction of the fracture only (1) after the patient recovers from shock, (2) after the swelling subsides, or (3) not until the open wound has healed. That no rest for the injured part can be provided under any of the above circumstances should be obvious to anyone who understands the principles of either Lister or Thomas.

We may take as an example the trophic changes that occur in the hand or fingers in cases of injury or damage to the forearm. Circulatory and trophic changes in the median and ulnar areas appear promptly and are striking and characteristic if anatomical relationship is not promptly restored. Protection of the patient in such a position that lymphatic, circulatory, and neurotrophic functions are restored to the part is the obvious indication.

Reduction of all the soft parts, as well as of the broken bones, is necessary if all the functions are to be resumed. Only under such circumstances is it possible for the individual's natural defenses to operate so that there may be a physiological restoration of the area.

The lack of understanding of the principles worked out by Thomas has been so general that it is not uncommon to observe Thomas' own splints inaccurately or inefficiently employed, and to see them modified by joints, screws, nuts, bolts, and other adjustment devices to the point where adequate control of the limb and the patient is impossible. Not only is this so, but injured and damaged limbs are often placed in such splints before correct position has been obtained. Fracture fragments and soft parts may be so shortened or rotated upon each other as to destroy any possibility of normal physiological function by the nerves, lymphatics, blood vessels, and other soft parts. The truth is that any form of elastic traction represents a violation of the fundamental requirements of immobilization in correct length and position. It might appear that the time has now arrived when reduction of most factures and deformities at the time of operation and fixation in plaster or some other equally efficient device (if any) should be done routinely instead of resorting to any form of postoperative traction. That is, traction should be employed always as an operative rather than as a postoperative measure, and fixation (also at operation), in whatever form may be necessary, should give us complete postoperative control.

The advantage of exact anatomical reposition for fractures and for diseased joints has been demonstrated anew in recent years by the wide employment of direct fixation methods as taught by Lane [8], Albee [1], and others. Even with the obvious disadvantages and dangers of operative internal fixation, the results in fractures have been so good that many surgeons and patients have cheerfully assumed the additional risk of open operation. If such operations could always be done by those equipped

and experienced, the method might be endorsed without reservation. As a safer alternative to these open methods, it has now been demonstrated satisfactorily that we may obtain length and position in plaster-of-Paris by means of pins included in the cast. By this method, neither pressure nor constriction is necessary, and, when primary reduction has been obtained, loss of position cannot occur.

The technique of internal splinting by bone grafts has at times been carried out so successfully that external splinting is unnecessary. In those cases in which adequate fixation cannot be secured by means of the graft alone, improper motion at the point of fracture may occur. Disturbance of the parts because of loss of position should generally be provided against by the use of skeletal fixation (rather than traction) in plaster-of-Paris as already suggested. This is a method which is almost universally applicable.

These considerations of restoration to correct anatomical relationship and of maintenance in suitable position for rest and subsequent function are fundamental to the practice of all surgery, but to orthopaedic surgery in particular. The devotion of the orthopaedic surgeon to these fundamental needs of the patient is what I think Sir Robert Jones had in mind when he spoke, as he often did, of the "orthopaedic conscience". The attitude of a surgeon toward these principles implies a proper respect not only for the fundamentals of orthopaedic practice, but for the essential needs of the patient. Under such circumstances and conditions, the patient's requirements as to protection against damage from the outside as well as against disturbance of his physiological functions are much more likely to be appreciated.

This is what enabled Thomas and his followers, many of whom have been in the front ranks of the American Orthopaedic Association, to make their contributions to surgery what they are today. This is illustrated by such a teaching as that of Dr. Phelps [16] of New York: "A tuberculous joint is not a purulent one, because the bacilli of tuberculosis are not pyogenic. When the joint becomes purulent it is because pyogenic germs . . . produce the condition known as osteomyelitis, which is one of the most destructive forms of joint-disease. Sinuses leading to non-purulent tuberculous cavities are the highways through which purulent infection travels. Knowing this, why not prevent the multitude of sinuses by operating and protecting the discharges from infection? I think that we should."

It is in the practice of orthopaedic surgery as a specialty that surgeons have shown the greatest interest in maintaining at all times the patient's parts in correct anatomical relationship for function. This has been one of the first items for consideration in our attempts to arrest disease, to prevent deformity, to lessen disability, and to restore the patient to his normal status. Our interest in these matters has inclined us to pay especial attention to protecting the patient and his injured or diseased areas against infection, and we have observed that it is only by the combination of the methods of Lister and Thomas, and of the best contribu-

tions of other surgeons, and orthopaedic surgeons in particular, that these ideals can be attained. It must always be kept in mind, however, that methods and techniques must infallibly conform to principles in order to be suitable for general adoption. We have often been the first to observe that dressing and splint methods have failed to conform to such principles and that they are for that reason not only improper but injurious. It is often, therefore, by a conservative attitude toward innovations, and not by devising gadgets, that we may make our contributions to a more complete realization of the ideals and possibilities of modern surgery. What we must endeavor to do is to so adhere to the fundamentals of the Lister idea that the putrefactive organisms will be kept out of the wounds and that this shall be done by the simplest measures possible. At the same time, the exclusion of infection affords the orthopaedic surgeon the opportunity to employ other principles—such as the principle of rest—with greater efficiency. To correct and to prevent deformity and to secure and to preserve all the best features of form and function will always be the aims of orthopaedic surgeons and of the specialty of orthopaedic surgery.

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THE TREATMENT OF FRACTURE-DISLOCATIONS OF THE CERVICAL VERTEBRAE BY SKELETAL TRACTION AND FUSION *

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The cervical spine is particularly vulnerable to injury because of the weight of the head and the mobility of the cervical vertebrae. When tense, the neck muscles, with the powerful ligaments, provide considerable protection, but, when the muscle defence is relaxed, the unexpected application of even a slight force may cause severe injury.

Indirect violence of various types is the usual cause of serious injury, producing at times extreme deformity. Fracture-dislocations easily produced are also readily reduced by prompt and appropriate treatment. Reduction can be maintained by plaster and other supporting jackets, but recurrence of the deformity may develop shortly after the support is removed, or the deformity may gradually increase over a period of years unless more energetic therapy is provided.

These observations are not new ones, — various surgeons have written on the problem, which is an important one, for, with recurrence of the deformity, nerve-root or spinal-cord involvement may result. It is the vulnerability of the spinal cord which makes the recurring deformities of such grave significance. Immediate death, due to respiratory paralysis, is not infrequent when the deformity recurs suddenly in the upper cervical region. Sudden transient quadriplegia, due to slight trauma, coughing, or sneezing, has occurred in some of the cases in our series. Slow development of spinal-cord signs, just as significant but not as alarming, have occurred more commonly.

In the past four years there have been under our care thirty-six patients with injuries to the cervical vertebral column, and in twelve of these the skeletal, muscular, and ligamentous involvement was such that operative intervention and fusion were carried out. It is because of the satisfactory end results obtained by fusion that the following representative case reports, discussion, and conclusions are presented.

FUSION FOR FRACTURE-DISLOCATIONS IN THE UPPER CERVICAL REGION

In 1907 Corner, under the title of rotary dislocations of the atlas, reported twenty examples,—eighteen from the literature and two from

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† Authors' names are arranged alphabetically in this joint report.

his own practice. Death followed soon after the accident in two of the twenty cases. In six, it resulted after a period ranging from twenty-three days to many years. Post-mortem findings in eight cases revealed more than rotary dislocations in every instance. In six, the odontoid was fractured; in one, there was a lateral fracture of the atlas; and in another, the fifth, sixth, and seventh cervical vertebrae were broken. Omitting the two rapidly fatal cases, in none of the other six were there spinal-cord symptoms at first. Corner points out that the absence of spinal-cord symptoms after trauma to this region makes it easy to overlook or to fail to appreciate the significance of injury to these parts, and that sudden death or the later development of paralyses is the penalty for failure to evaluate properly such injuries.

The following case emphasizes the correctness of Corner's conclusions, but fusion has altered the prognosis which he advised should be guarded. Now the occiput is fused to the cervical vertebrae and the patient is safely restored to his usual activity.

Case 1.* *Progressive Occipito-Atlanto-Axial Dislocation. Fracture of the Odontoid Process.* (See Figures 1-A and 1-B.)

Dr. V. L., at the age of forty-two, was thrown through the windshield of his car. Unconsciousness lasted for two or three days. He had sustained multiple lacerations about the face and the head, five broken ribs, and a hemothorax. As soon as he recovered consciousness he observed that the neck was stiff and there was crepitus on movement.

For months after the accident the neck was massaged. Always some limitation of motion was present and at times the discomfort was marked.

In spite of the constant stiffness and periodic pain, the patient carried on his general practice for sixteen years. On May 14, 1935, at the age of fifty-eight, he was attending an obstetrical case and instrumental delivery was necessary. As he was making traction, the forceps dislodged. He slipped forward and noted a sudden numbness and tingling in the finger tips of both hands and weakness of the arms and the legs. The numbness continued, and the weakness of the arms increased until he did not have enough strength to unscrew his fountain pen. The neck was not painful if he reclined. He could not remain in the erect position without some support to the head, because the pain became intense and the power in the arms diminished.

With the limited activity which the pain imposed, he carried on until August 1, when, following a sudden movement, he again became weak all over and every muscle in the body ached.

On physical examination, the neck was rigidly splinted. The upper cervical spines were more prominent than usual and tender. The deep reflexes were symmetrically present and active throughout. Of the superficial reflexes, all were normal except the great-toe movements. The tests of Gordon, Oppenheim, Chaddock, and Babinski all caused the great toe to move up. Muscle strength in both upper extremities was reduced and fine finger movements were awkward. Although the patient complained of some weakness in the legs, it was not great enough to show as he walked.

No objective sensory changes could be demonstrated anywhere. He complained of paraesthesia and hyperaesthesia in the hands, particularly in the finger tips, and volunteered the information that at times when he walked the feet felt as though thick, soft insoles were in his shoes. In spite of this, the vibratory sense and the sense of position were normal everywhere.

* Referred by Dr. Jean Saucier.

The lumbar manometric test showed a complete block and there were 51.4 milligrams of total protein per 100 cubic centimeters in the spinal fluid.

Dr. A. E. Childe reported on the roentgenographic studies as follows: "Stereolateral views of the cervical vertebrae show an anterior dislocation of the skull and the axis on the atlas with an associated fracture of the odontoid. The odontoid process lies about 1.5 centimeters posterior to its normal position. Views of the odontoid through the open mouth show its outline to be fairly regular. There seems to be some narrowing of the articulations between the axis and the atlas. There is also the appearance of old trauma to the fourth and fifth cervical bodies indicated now by hypertrophic bony changes."

Following the preoperative diagnosis of progressive occipito-atlanto-axial dislocation and fracture of the odontoid, decompressive laminectomy and fusion were carried out on August 15, 1935.

The posterior arch of the atlas was well forward, pressing on the dura. The spinal cord had been exposed below this through a unilateral laminectomy, leaving the spinous

Fig. 1-A Fig. 1-B

Case 1. Progressive occipito-atlanto-axial dislocation.

Fig. 1-A: Before operation.
Fig. 1-B: After operation. The posterior arch of the atlas has been removed and the bone grafts run from the occiput to the sixth cervical spine.

processes intact. Pulsations with respiration or heart beat did not take place until the posterior arch of the atlas was removed; they then began at once and jugular compression caused large amounts of fluid to pour out from above.

Bone for grafting was taken from the right ilium. With the Hudson burr openings were made in the occipital bone, one centimeter to either side of the midline and one centimeter above the posterior arch of the foramen magnum. Through these openings, the dura was separated from the skull and protected while small drill holes were made. The pedicles of the first cervical vertebra were drilled and drill holes were placed through the spines of the cervical vertebrae. Through the various drill holes were passed ligatures with which the parallel bone grafts were tied to the cervical vertebrae and to the occiput. The parallel bone grafts extended from the occipital bone to the level of the sixth cervical spine. Rustless-steel wire, introduced by Babcock, was the suture material used to tie the grafts in place and to close the muscles in layers over them.

When the fusion was completed, the patient was transferred to his bed, and, through small burr holes in the skull, heavy rustless-steel wire sutures were passed, so that immobilizing skull traction would be possible until wound healing was complete and an immobilizing cast could be applied.

Nine weeks after operation the patient was discharged from the hospital, wearing a modified Minerva cast and walking. Lumbar manometric tests showed no evidence of block. Plantar reflexes were in flexion. Power in the hands had returned and the paraesthesia and hyperaesthesia of the fingers had disappeared.

Five months after the operation he was doing limited practice, wearing a neck support. After six months, all support was removed. He gradually increased his work until at the end of one year his activity had been fully resumed. On the first anniversary of the operation he made complete rounds with the surgical staff, occupying a period of four hours, and was not overfatigued. He cannot rotate the head and this hampers him in conversation and in traffic. This is now the only disability which he has. Roentgenograms show that the fusion is solid from the occiput to the sixth cervical vertebra.

Kahn and Yglesias have reported the history, findings, and treatment of an almost identical case. In their case, it was also necessary to remove the posterior arch of the atlas to decompress the cord, and the bone grafts were taken from the ilium. Their patient was restored to complete activity and felt that he was in no way handicapped by the fusion. The problem in such patients is similar to that of lumbar spondylolisthesis and the term "cervical axial spondylolisthesis" might be used to describe it.

CASE 2. *Fracture through the Base of the Odontoid Process with Backward Displacement.* (See Figures 2-A, 2-B, 2-C, 2-D, 2-E, and 2-F.)

F. P., aged fourteen, was referred by Dr. J. H. Mason of Lachute, Quebec, on July 25, 1935. To Dr. Mason's skillful supervision in transporting him to the hospital, the lad owes his life. On the afternoon of admission, he had fallen backward off a load of hay, striking the back of the head. He did not lose consciousness; he heard a loud crack in his head, the arms and legs were numb, and all power was lost. After a short period, he was able to move the legs a little and later could wiggle the arms a bit.

On admission, the most marked symptoms were pain and hyperaesthesia in the distribution of the second and third cervical dermatomes and pain in the neck. The patient screamed with pain caused by the lightest touch or a current of air striking the upper neck or chin and would not talk because movements of the lips or chin shifted the skin in the upper cervical region and caused pain. Any neck movement caused severe pain and gentle palpation was very painful. There was no obvious deformity.

The tendon jerks were hyperactive in the arms and legs; the abdominal reflexes were obtained with difficulty; the cremasterics were absent; plantar stimulation caused upward movements of the great toe on both sides.

The arms and legs were very weak, although no complete paralysis of any muscle group was found. Breathing was almost entirely thoracic.

Below the second and third cervical vertebrae, where the hyperaesthesia and spontaneous pain were so striking, there was complete loss of pain and hypaesthesia for touch over most of the right arm and slight hypaesthesia for all forms of sensation on the trunk up to the fourth thoracic dermatome.

Fig. 2-A

Fig. 2-C

Fig. 2-E

Fig. 2-B

Fig. 2-D

Fig. 2-F

Case 2. Fracture through the base of the odontoid process with backward displacement.

Fig. 2-A: Film taken through the mouth immediately after admission, showing the laterally tilted odontoid and fracture through the base.

Fig. 2-B: Lateral view on admission. The odontoid is tilted back.

Fig. 2-C: Film through the mouth, taken immediately after traction was applied. The odontoid is now in the midline.

Fig. 2-D: Lateral view immediately after traction. The odontoid is vertical. The rustless-steel wire sutures through burr holes are in place and to these traction had been attached.

Fig. 2-E: View through the mouth after fusion. Reduction has been maintained and the parallel bone grafts are in place.

Fig. 2-F: Lateral view after fusion. The odontoid alignment is normal. The grafts extend from the first cervical vertebra to the fourth.

Both the lateral roentgenograms of the neck and the anteroposterior roentgenogram through the mouth showed a fracture through the base of the odontoid process.

Under local anaesthesia, with a Hudson burr, small openings were made in the skull into which heavy rustless-steel wire sutures were inserted, enabling skeletal traction to be applied.

Just as soon as the traction was applied, further roentgenograms were taken; these showed the odontoid in good position. The patient was very much more comfortable with the immobilization which traction provided and could be turned without pain. Lumbar manometric tests showed no block.

On August 17, with traction still on, the cartilages of the articular facets in the upper cervical vertebrae were curetted away. A curved piece of rib was removed and split, and the halves were laid parallel to each other—one on the right and one on the left side of the cervical spines—in contact with the laminae and tied in place with rustless-steel wire sutures. It was hoped that a fusion of the first, second, third, and fourth cervical vertebrae would develop as a result of the procedure.

A modified Minerva cast was applied on September 4, and the skeletal traction was removed on that date. One week later the patient was allowed up and, as practically all signs had cleared up, he was permitted to walk. He was discharged from the hospital on October 17, 1935, a little less than three months after admission.

This lad returned to school in January, about six months after the accident. Roentgenograms, one year after operation, showed the odontoid in normal position and an apparently excellent fusion. His posture, that of a patient with a stiff neck, was excellent and, since only four cervical vertebrae were fused, he had an amount of mobility which caused him no handicap.

The impression that the odontoid once fractured never unites by anything but fibrous union has been handed along, due, perhaps, to the fact that deformities so often develop years after injuries to the upper cervical region, as in Case 1. In the last roentgenograms of the patient in Case 2 there seems to be bony union and we have the impression that with adequate reduction and immobilization this may be expected in most cases. We feel that this patient's prognosis is excellent and does not need to be guarded.

CASE 3. *Comminuted Fracture of the Anterior Arch of the Atlas and Dislocation of the Left Articular Facet of the Atlas.* (See Figures 3-A, 3-B, and 3-C.)

E. G., aged six, was referred by Dr. John Kershman on April 10, 1936. While playing, he was pushed off a stairway and fell backward, sliding down seven stone steps, striking the head or neck on each riser on the way down. He held the head rigidly, slightly rotated and tilted to the right and he would not bend the neck. He complained of pain in the neck and in the occipital region. Dr. Kershman had found that with pillows under the shoulders, allowing the neck to be hyperextended by the weight of the head, the neck discomfort and occipital pain disappeared.

From the neurological standpoint, the only abnormality found was hypaesthesia over the distribution of the second and third cervical dermatomes bilaterally. There was no spinal subarachnoid block.

Roentgenograms showed a comminuted fracture of the anterior arch of the atlas and a dislocation of the left articular facet of the atlas. There was a soft-tissue swelling in front of the injured vertebra, a point to which Dr. Childe has called attention in other similar cases. It is due to hemorrhage under the prevertebral fascia, which pushes it forward.

On April 15, 1936, the occiput and the laminae of the cervical vertebrae were exposed. The posterior arch could be freely moved on the left side, due to a false point of motion in the region of the left articular facet. No other obvious abnormality was noted.

A rib was removed and split longitudinally, and the halves were laid against the laminae of the first, second, and third cervical vertebrae,—one on the right and one on the left. Rustless-steel wire sutures around the posterior arch of the atlas anchored the parallel grafts at the upper limit. Through drill holes in the spines of the second and third cervical vertebrae, the grafts were held tightly to the laminae.

Skeletal traction was applied to the skull, using heavy rustless-steel wire sutures.

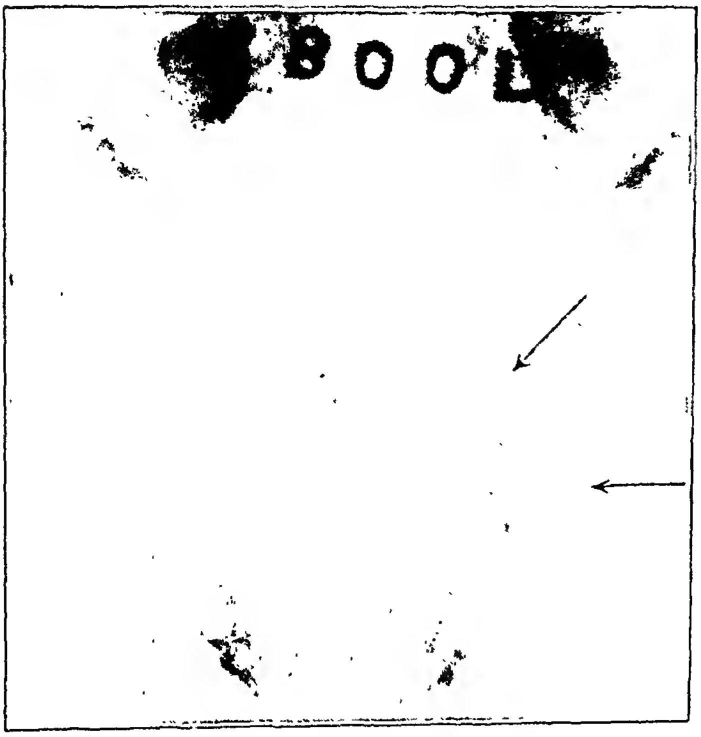

FIG. 3-A

FIG. 3-A, FIG. 3-B, AND FIG. 3-C

Case 3. Comminuted fracture of the anterior arch of the atlas and dislocation of the left articular facet of the atlas.

Fig. 3-A: Film of the base, showing the anterior arch of the atlas and the atlanto-axial articulations. Arrows point to the fractured arch and the dislocations of the left facet.

Fig. 3-B: Lateral view, showing abnormal posture and a retropharyngeal shadow due to hemorrhage.

Fig. 3-C: Lateral view after fusion. The parallel bone grafts are shown tied in position from the atlas to the fourth cervical vertebra. The retropharyngeal hematoma has absorbed.

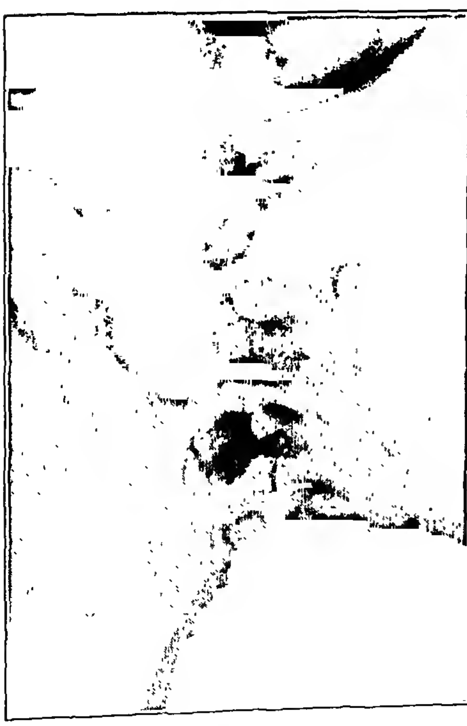

FIG. 3-B

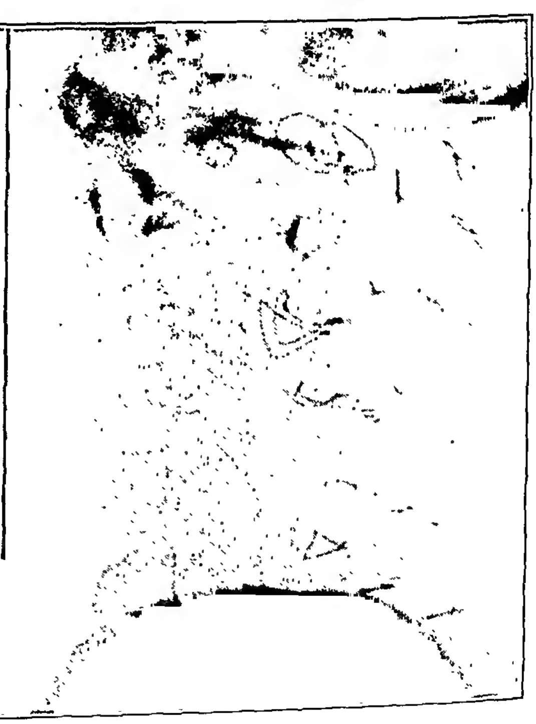

FIG. 3-C

On May 5, 1936, a modified Minerva collar was applied and the skeletal traction was then removed. The patient was discharged from the hospital, symptom-free neurologically, on May 16, 1936. He wore the cast for four months and then a compression collar for two months.

Ten months after the operation, he had no apparent disability. He held the head a little stiffly, but movements were surprisingly free. Roentgenograms showed the grafts well in place, fusing the first, second, and third cervical laminae.

One point deserves special emphasis in this case. The soft-tissue swelling in the retropharyngeal region was described by Dr. Childe in the first lateral views taken and the abnormal cervical curvature in these films made it seem from the roentgenographic standpoint that there had been an injury to the upper cervical spine. Roentgenograms taken through the open mouth did not disclose the nature of the injury and it was not until films of the base of the skull were obtained that the fracture was proved.

FUSION FOR FRACTURE-DISLOCATIONS BELOW THE THIRD CERVICAL VERTEBRA

The fact that late deformities develop after an entirely satisfactory reduction of fracture-dislocations and an adequate period of immobilization is not as surprising here as it is at the higher levels. The weight of the head acts on a longer lever and exerts more force on the injured part. It has seemed clear to us that the greater the ease and rapidity of reduction, the greater is the likelihood that later deformities may develop. When the injury is a complex one—in which bodies, articular facets, pedicles, and laminae are injured—reduction is often surprisingly simple. Even the weight of the head in hyperextension will at times bring about the reduction, and it is especially in these cases that fusion is indicated.

CASE 4. *Relapsed Fracture-Dislocation of the Fourth on the Fifth Cervical Vertebra.* (See Figures 4-A, 4-B, 4-C, 5-A, and 5-B.)

R. B., aged forty-two, referred by Dr. J. Boulay, Sutton, Quebec, came under supervision first on March 18, 1934. He had suffered a forward dislocation of the fourth cervical vertebra on the fifth, a fracture of the pedicle and the articular-facet elements between the fourth and the fifth vertebrae, and a fracture of the body and right lamina of the fifth vertebra.

He was almost completely paralyzed in both upper extremities and the legs were weak. The sensory level was at the fifth cervical segment. Reduction was promptly and painlessly accomplished with neck-halter traction and weights attached over a pulley, and the patient was immobilized in plaster. The neurological signs cleared up slowly; the lumbar manometric test showed no block and the patient was discharged three months after admission, walking and wearing a plaster cast and arm brace. The vertebral alignment was perfect.

Nine months later the deformity had relapsed in the cast. The patient had begun to have more neck pain and referred pain over the left shoulder. The roentgenogram showed a deformity more extreme than that present on the first admission and there appeared to be a solid fusion which we could not alter.

The patient was admitted to the hospital on June 19, 1935. Wire skull traction was applied with heavy weights, which brought about no change in the malunion. On June 24, 1935, he was operated upon and the cervical vertebrae were exposed. The laminae of the fourth and fifth cervical vertebrae over the apex of the deformity were removed and

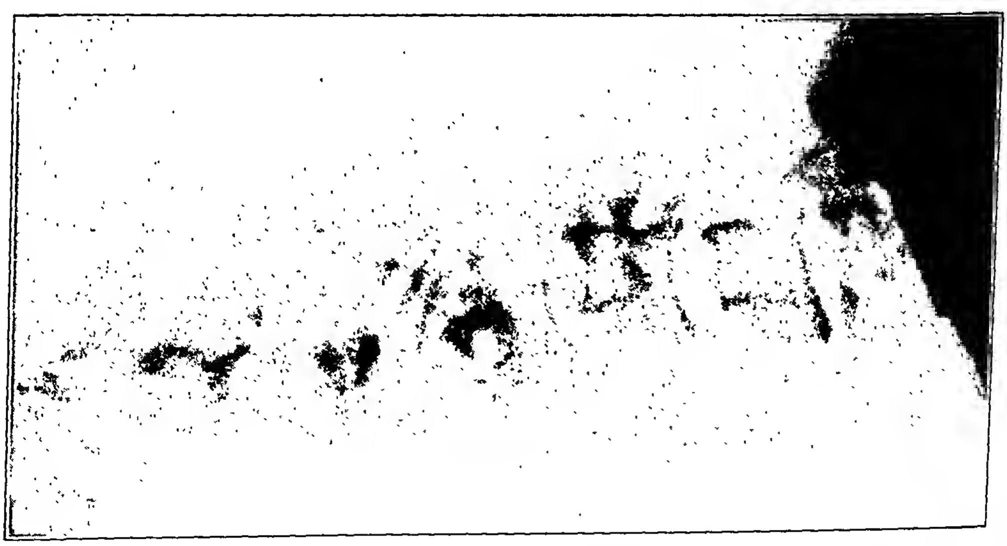

Fig. 4-A

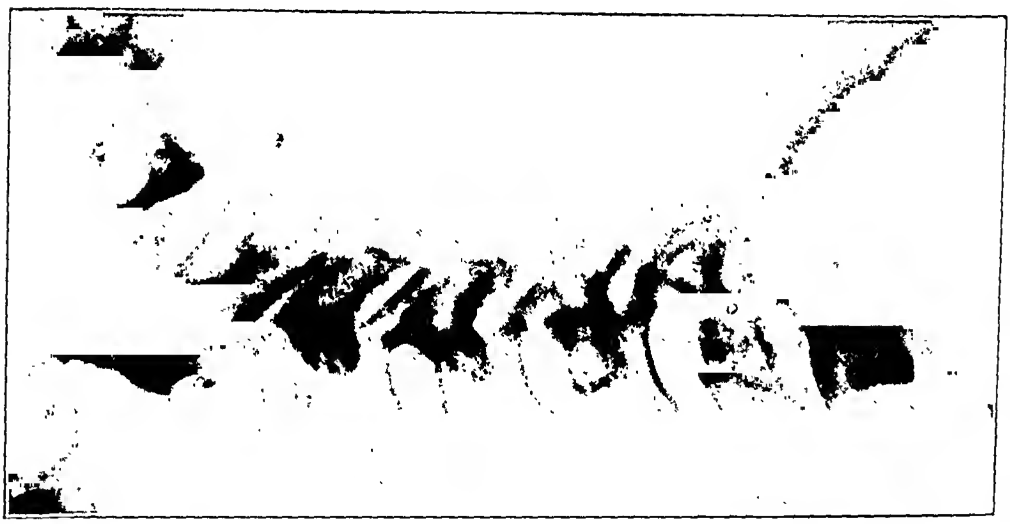

Fig. 4-B

Fig. 4-C

Case 4. Lateral films, showing:
Fig. 4-A: Initial deformity; Fig. 4-B: Reduction by traction; and Fig. 4-C: Satisfactory alignment after the cast was applied.

parallel tibial grafts were solidly moored from the second cervical vertebra to the seventh cervical vertebra with quite extensive bony contact. These furnished an excellent bony bridge. Seventeen days later, a head and neck torso plaster was applied and the traction wires were removed. The patient was discharged on August 27, 1935. The neck was protected for five months after the operation.

Twelve months after operation he was reemployed as a railway-crossing tender and his work has been satisfactory since that date. The roentgenograms show increased consolidation of the graft. There is extensive limitation of flexion and rotation. His endurance is good and the traffic does not bother him.

CASE 5.* *Old Fracture-Dislocation of the Fourth on the Fifth Cervical Vertebra with Advancing Spinal Compression.* (See Figures 6-A, 6-B, and 6-C.)

K. S., aged thirty-eight, struck his head on August 18, 1935, while swimming. He rolled on his back, was conscious, but could not move. After two or three days in another hospital, motion in the limbs gradually improved. During this time he had halter traction and later a plaster was applied, which he wore until November. He was

* Referred by Dr. F. H. Mackay.

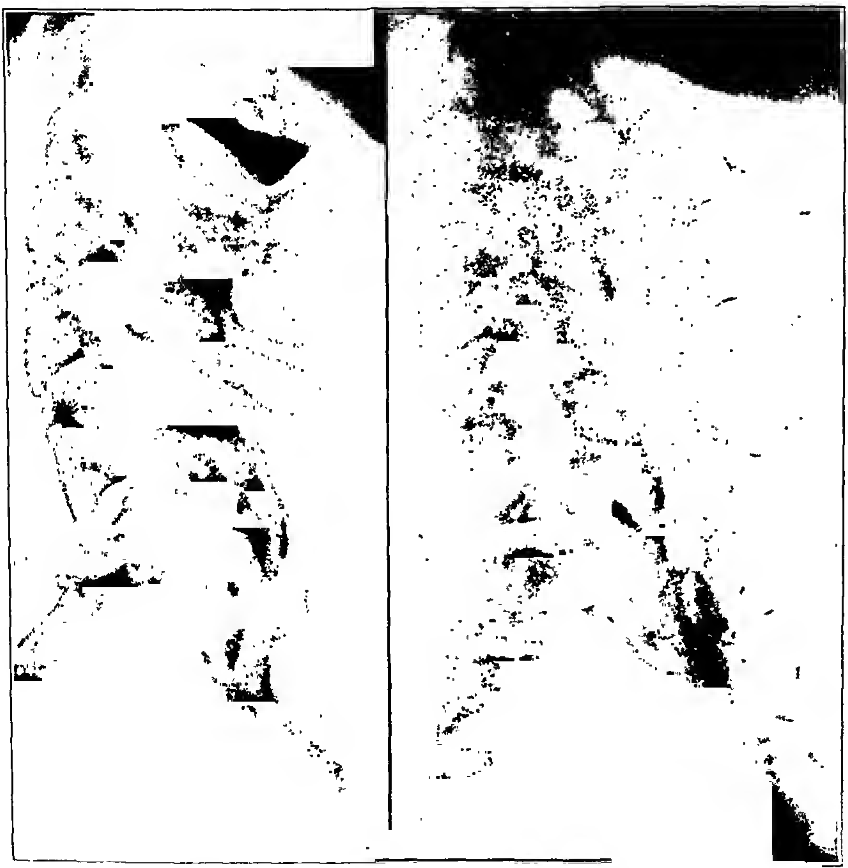

FIG. 5-A FIG. 5-B

Case 4. Relapsed fracture-dislocation of the fourth on the fifth cervical vertebra.

Fig. 5-A: The deformity found nine months after the injury. The relapse had occurred while the patient was still in the cast.

Fig. 5-B: Lateral film after decompressive laminectomy and fusion.

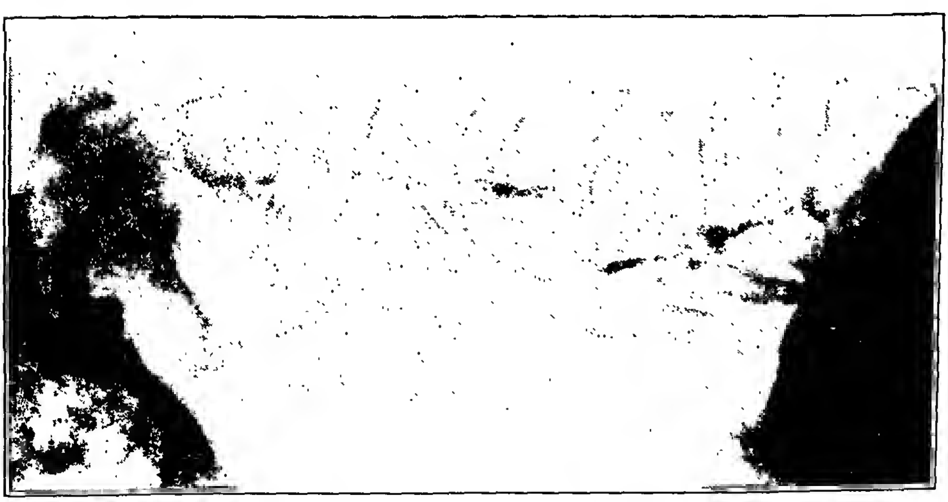

Fig. 6-A

Fig. 6-B

Fig. 6-C

Case 5. Old fracture-dislocation of the fourth cervical vertebra on the fifth.

Fig. 6-A: The deformity present at the time of admission. Although the reproduction of this film does not show it, there was a bony bridge extending from the anterior and inferior part of the body of the dislocated fourth to the body of the fifth.

Fig. 6-B: The bony fusion has been broken by heavy skeletal traction.

Fig. 6-C: This film shows the eventual reduction obtained on the operating table and the bone grafts.

admitted to this hospital on November 12, 1935. He was extremely anxious because the power which he had regained in the hands after the accident was diminishing and he could not carry on any longer as a technician in charge of a serological laboratory.

The roentgenograms showed a fracture-dislocation of the fourth cervical vertebra on the fifth and a compression fracture of the body of the fifth cervical vertebra and bony fusion of the deformity. Although the lumbar manometric test showed no definite subarachnoid block, the total proteins in the cerebrospinal fluid were 65.8 milligrams per 100 cubic centimeters.

Because of the disability of the hand and the weakness of the legs, operation was advised. Heavy skull traction broke the fusion of the bodies anteriorly, but the fusion of the articular facets was too firm to permit any change in the deformity. On November 15, 1935, on the operating table about thirty pounds of traction was maintained. The vertebrae were then exposed and the laminae of the fourth and fifth cervical vertebrae were removed. There was no change in the deformity until the facets between the fourth and fifth vertebrae were rongeured away and, as the last portions were removed, reduction and realignment slowly took place without manipulation. Parallel rib grafts were then firmly bound with fine rustless-steel wire to the laminae of the second, third, sixth, and seventh cervical vertebrae. The articular cartilages of the facets not already removed were curetted away.

The patient's postoperative course was smooth and the neurological condition improved steadily. As soon as possible a modified Minerva plaster was applied and the wire traction was removed. This support was continued for six months. At the end of this period, the patient had completely recovered and resumed his work with some limitation of neck movements but with no discomfort. One year later, solid fusion of the bone graft was demonstrated by x-ray.

In this case, the laminae of the fourth and fifth cervical vertebrae were removed, so that the grafts had good contact with only the second, third, sixth, and seventh cervical vertebrae. Yet, one year later, the bony bridge showed solid fusion and some increase in size of the grafts. If we had carried out the same procedure in Case 4, unlocking the fused facets, it is possible that this patient's deformities might also have been reduced.

CASE 6. *Fracture-Dislocation of the Sixth Cervical Vertebra on the Seventh with Marked Instability.* (See Figures 7-A, 7-B, and 7-C.)

G. M., aged forty-seven, was referred on May 12, 1936, by Dr. Warren Lynch, of Sherbrooke, Quebec. Seven days prior to coming under our supervision, the patient had fallen from a roof onto her head, producing a fracture-dislocation of the sixth on the seventh cervical vertebra. She was conscious and able to crawl to the house to await assistance. The first treatment was continuous traction with a neck halter. Partial reduction was obtained, but pressure sores developed on the chin and over the occiput and, when traction was removed, the deformity recurred. Four days after the injury, skeletal traction was applied to the skull with rustless-steel wire sutures, and a frame was improvised, so that traction could be maintained during transportation by ambulance from Sherbrooke to Montreal.

Upon her arrival at this hospital, the usual apparatus for skeletal traction was used and an operation was carried out with skeletal traction still immobilizing the neck. The cervical and upper thoracic vertebrae were exposed. The comminuted facets of the sixth and seventh cervical vertebrae were removed and the fractured laminae and spine of the sixth cervical vertebra were lifted away. The sharp bone fragments had lacerated the dura, so that cerebrospinal fluid had percolated into the neck muscles and poured out, filling the field during the procedure. The dura was not opened because pulsations were free and there was no evidence of block. Bone grafts were removed from the tibia and fixed in contact with the laminae by rustless-steel wire sutures passed through drill holes in the base of the spinous processes. The fusion included the third, fourth, fifth, sixth,

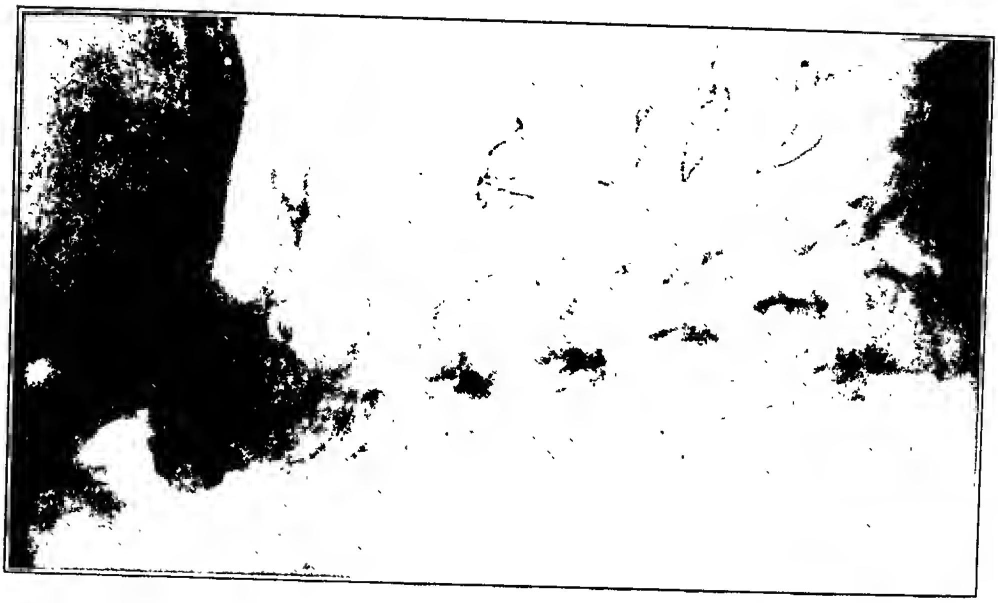

Fig. 7-C

Fig. 7-B

Fig. 7-A

Case 6. Fracture-dislocation of the sixth cervical vertebra on the seventh with marked instability.

Fig. 7-A: The initial deformity (films taken by Dr. Warren Lynch of Sherbrooke).

Fig. 7-B: The reduction obtained by traction.

Fig. 7-C: Lateral film after laminectomy and fusion.

and seventh cervical vertebrae and the first and second thoracic vertebrae. Postoperative roentgenograms showed that reduction was maintained. The wounds healed perfectly, despite an attack of pyelitis, and, on June 3, 1936, plaster fixation was applied and skeletal traction was then removed. The patient was discharged from the hospital on June 28, 1936, walking.

She steadily gained strength and when she returned for follow-up examination, five months later, the only objective abnormal neurological findings were hyperactive deep reflexes throughout, more ready fatigability of the right abdominal reflexes, slight diminution of temperature sensation over the left foot, and unusual sweating of the hands and particularly of the feet. The vertebral alignment was excellent. The bone grafts seemed to have slightly increased in size and appeared to be fusing well.

It is surprising that the spinal cord escaped with so little damage. The deformity was extreme and the comminution extensive, and tiny sharp bony fragments had torn the dura and opened the arachnoid.

Although fair reduction was obtained by traction, the extensive comminution and instability necessitated complete exposure, accurate reduction under direct vision, and fusion; otherwise, added damage to the spinal cord would surely have occurred.

DISCUSSION

We have presented the case histories of six of the twelve patients whom we have treated by bone grafting, and these cases illustrate our indications for fusion. Of the other six patients, three were referred after late deformities had developed and spinal-cord involvement was advancing. In these three cases the operations were considered operations of necessity and not of election. Two patients had atlanto-axial dislocation with fracture of the odontoid process. In the twelfth case, although roentgenographic evidence was lacking, because of the neurological findings, we assumed that the patient had suffered an atlanto-axial dislocation which had spontaneously reduced. Respiratory movements would cease when this patient was shifted and we did not dare to attempt roentgenographic studies in the positions in which the dislocations recurred. Operation was done with the neck immobilized by skeletal traction on the operating table. The exposure was carried out under local anaesthesia, the bone graft being removed from the tibia without any anaesthesia because sensory loss was complete. This patient is walking and has some use of the hands. The diagnosis at discharge was upper cervical hematomyelia, due to atlanto-axial dislocation. The paralysis of the neck muscles, due to a lesion of the anterior-horn cells, was one of the indications for fusion. In spite of this, the fusion is satisfactory eight months after operation.

We have followed a rather rigid routine in handling and studying the acute injuries after admission to the hospital. Neurological and general physical examinations are just as complete as the patient's condition will permit. In many instances much of the examination has been carried out in the x-ray room in the intervals between x-ray exposure and the development of the films. As a rule, we do not move the patient from the

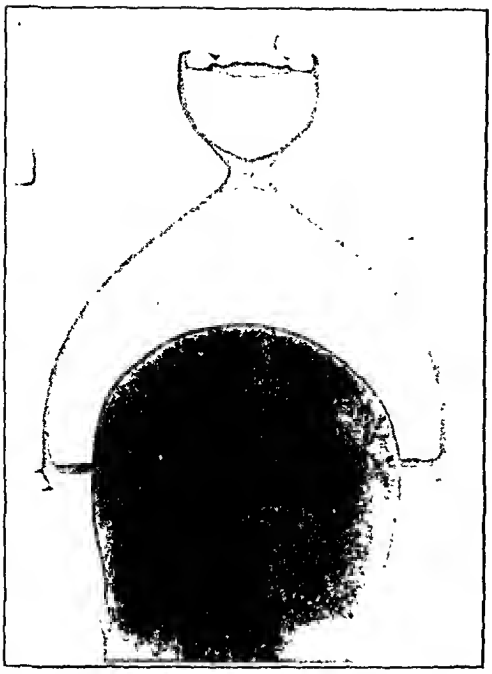

FIG. 8

Tongs for skeletal traction designed for us by Dr. Lyman G. Barton, Sr. They are shown in place on the skull of the patient whose cervical x-rays are shown in Figs. 10-A to 10-F.

bed for the roentgenographic studies; lateral films are taken with cassettes held at the side and pushed down into the mattress. Roentgenograms taken through the open mouth and anteroposterior views of the other cervical vertebrae are obtained only when the attending physician is present to immobilize the head manually as the film holders are being placed. The bodies, pedicles, facets, and laminae have usually been well defined and a most valuable anatomical diagnosis has been the result. The roentgenogram of the base of the skull is invaluable for visualization of the anterior arch and the articular facets of the atlas. For this, the patient must be shifted to the x-ray table.

Lumbar manometric tests are then carried out with the same meticulous care. Digital compression of the jugular veins is not used, but, to block the venous return from the head, a blood-pressure cuff is placed around the neck with its manometer attached and then the exact amount of compression is known[4]. If roentgenograms have shown a deformity and a subarachnoid block is present, skeletal traction is applied with the patient in bed. To obtain traction, we use tongs designed for us by Dr. L. G. Barton, Sr. (Fig. 8), or heavy rustless-steel wire through small open-

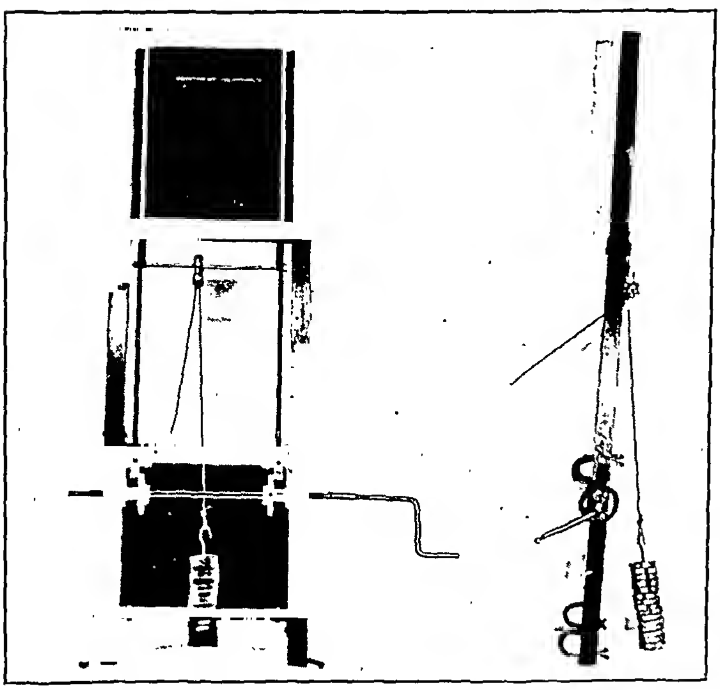

FIG. 9-A FIG. 9-B

Fig. 9-A and Fig. 9-B

Anterior and lateral views of traction frame. Any angle of traction can be obtained and the pulley on the cross-bar moves from side to side, so that, when the patient turns or is shifted to either side of the bed, the traction pulley shifts automatically and simultaneously.

ings in the skull made with a trephine or a Hudson burr. (See Figure 2-D.) The apparatus (Figs. 9-A and 9-B), designed, made, and presented

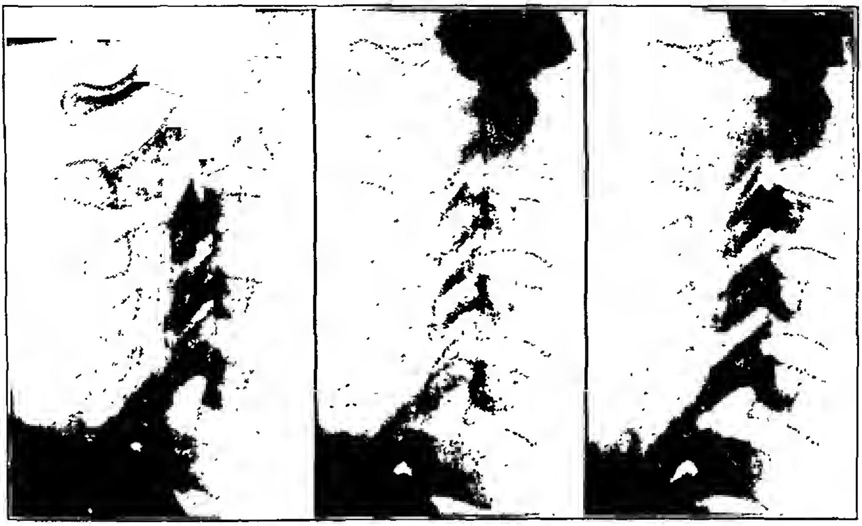

Fig. 10-A Fig. 10-B Fig. 10-C

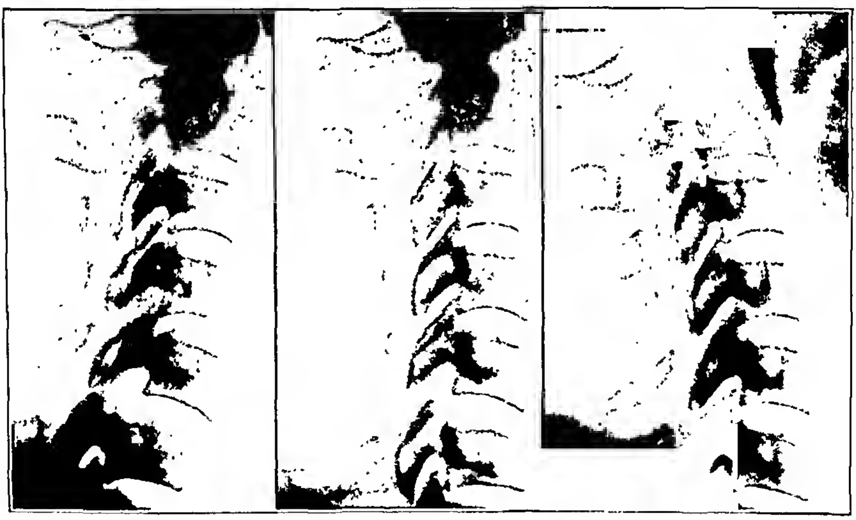

Fig. 10-D Fig. 10-E Fig. 10-F

Fracture-dislocation of the fifth cervical vertebra on the sixth, showing the initial deformity and the various stages of reduction.

Fig. 10-A: Deformity on admission. The articular facets are locked.

Fig. 10-B: After ten minutes of traction.

Fig. 10-C: After twenty minutes of traction.

Fig. 10-D: After thirty minutes of traction. The articular facets have separated and the deformity is less.

Fig. 10-E: The deformity is corrected. The articular facets have been unlocked.

Fig. 10-F: The bed gatch has been elevated and the traction lowered, and the weights have been reduced from twenty-five to eight pounds, allowing hyperextension of the neck and engagement of the articular facets in their normal position.

Before reduction, there was a complete manometric block. Immediately after reduction, the test was repeated and the block was found to have been completely relieved.

to us by Mr. G. H. Duggan, has contributed greatly to the simplicity of reduction and the comfort of the patients. It can be quickly attached to the bed, and the vertical screw arrangement permits the angle of traction to be altered slowly and smoothly. By altering the bed gatch and this angle of traction, reduction is facilitated. Figures 10-A to 10-F inclusive show how reduction is obtained by these two measures without any other manipulation and with but little discomfort. In this case, traction at first was made in the line of the upper cervical vertebrae,—that is, in the line of the deformity, to avoid leverage at the site of the fracture. When the articular facets were disengaged, the gatch was elevated and the traction bar lowered. The progress was followed with roentgenograms every ten minutes and reduction was complete after fifty minutes. Before reduction, there was an absolute manometric block which was found to be relieved when the test was repeated after the last roentgenogram was taken. This case is cited to show the value of this technique of reduction. The facets were not fractured and the bodies were intact. The indications for fusion, we felt, were not present. McKenzie, Crutchfield, and Hoen have shown the value of skeletal traction. Once the traction has reduced the deformity and relieved the block, the safety of the spinal cord is assured as long as the proper angle of traction is continued. The apparatus described has permitted lateral movements of the traction pulley on the cross-bar and allows the patient to be turned safely for back care and dressings. (See Figure 11.)

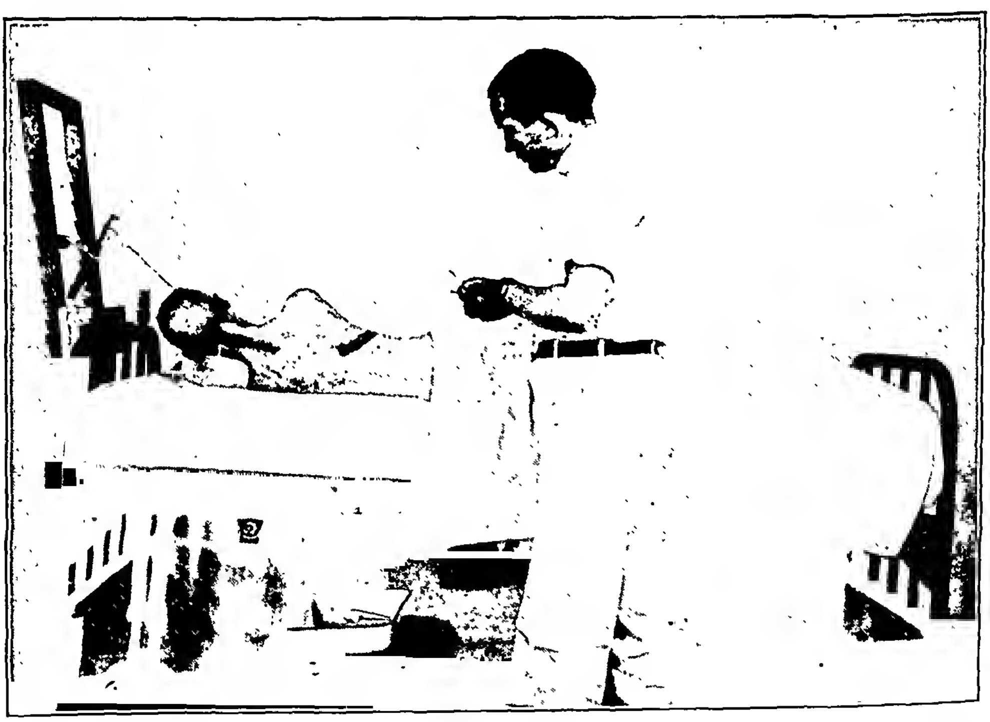

Fig. 11

Skeletal traction simplifies the postoperative care of patients. Turning can be accomplished with very little discomfort and without disturbing the alignment. Dressings are easy and the nursing care is simplified.

This photograph, demonstrating a dressing being done on the patient in Case 2, shows the cervical incisions and the incision over the rib where the graft was obtained.

FIG. 12

At operation, showing upper cervical fusion for fracture of the odontoid. The rib has been split and the two halves have been tied against the laminae with rustless-steel wire sutures through drill holes in the spines.

We want to emphasize three points in the surgical technique of the fusions. First, traction is maintained during operation. We have seen reduction take place on the operating table (Case 5) due to the traction alone without any manipulation other than that of rongeuring away bone which had fixed the facets. Secondly, because the exposures must be obtained by the gentlest means possible, we have dissected with the electrosurgical unit, baring the spines, laminae, and articular facets, and have avoided using periosteal elevators as much as possible. This has completely denuded the bone and prepared a bed for the grafts. Hemorrhage is minimal. Thirdly, we have used Babcock's rustless steel to tie the grafts in place and to close the muscles in layers over them. This suture material is easily handled, it is positively sterilized by boiling, and we have found by animal experimentation that there is less tissue reaction about it than with catgut or even with silk. It stays tied.

The bone grafts have been taken either from rib, tibia, or ilium. If a rib is to be used, drapings can be arranged so that but one operative field is prepared and a curve of rib can be chosen which may be better fitted to the spine. Tibial grafts have been satisfactory. The ilium gives flexible ribbon grafts which are readily adaptable in occipital cervical fusions (Case 1) and supplemental grafts can be easily obtained when required.

In all cases we used parallel grafts. (See Figure 12.) Articular facets above and below the lesion have frequently been curetted.

In this series of cases, where grafts have bridged the space of one or two arches without bone contacts at this level, the grafts have nevertheless survived, as noted in cases reexamined from six months to four years after operation, with increase in size of the grafts as shown by the roentgenogram.

As soon as the wound permits, plaster fixation of the head, neck, and torso is applied and the skeletal traction is removed. It is wise to have these patients up as soon as their motor power is adequate and they have

become accustomed to the plaster fixation. The patients are much happier and their general health is better. The plaster immobilization should be maintained for six months.

SUMMARY

Skeletal traction has been proved to be of great value in the reduction and immobilization of fracture-dislocations of the cervical spine, especially when the bed frame with its vertically movable, pulley-carrying cross-bar is used.

From our experience, we have concluded that fusion is indicated when more than one of the bony structures are injured. In fracture of a body alone, fusion is not necessary, but it is advisable in multiple fractures. We feel that when fracture of the odontoid is present, even though there is no other demonstrable vertebral injury, the patient is safer with fusion. When deformities recur after reduction, in spite of careful immobilization, fusion is imperative. Another important indication for fusion in high cervical lesions is paralysis of the neck muscles, due to cell involvement of the anterior horn. We feel that these conclusions are not radical. With fusion, the patient is protected immediately and from late recurrence of the deformity. Fusion not only insures much greater protection, but it allows the natural repair of the damaged vertebra to take place. In the occipitocervical fusions, rotation is lost, but considerable compensatory flexion remains. Below this level, the amount of mobility depends on the extent of the fusion. In this series the patients have resumed their previous activities and have not complained. The follow-up periods range from nine months to four years.

The age of the patients has ranged from six to seventy-two years. There have been no deaths and in none of the cases has there been wound infection. The twelve cases represent our total experience with fusion in the cervical region following trauma.

We wish to express our sincere thanks to Dr. Arthur Childe, radiologist, and to Mr. Walter Whitehouse, radiological technician, for their unfailing interest and cooperation.

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SPINAL DEFORMITY FOLLOWING TETANUS AND ITS RELATION TO JUVENILE KYPHOSIS †*

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INTRODUCTION

The first case of spinal deformity following tetanus was reported in 1907 by Lehndorff. Since Ehrlacher reviewed ten cases and added two of his own in 1921, the number reported in the literature has steadily increased. There may be several reasons for the infrequency of reports of this condition previous to recent years:

1. In young children, especially in infants, kyphosis, or kyphoscoliosis following generalized tetanus, is usually of a transient nature.
2. Lesser grades are observed only through roentgenographic examination of the spine, in which good lateral views are necessary to show changes in contour of the vertebral column as a whole, as well as alterations in the vertebral bodies themselves.
3. The condition is liable to be overlooked in patients, because it is relatively infrequent in adults, the appearance does not always follow immediately on the heels of recovery from tetanus, and moderate degrees are likely to escape observation.
4. The mortality following severe attacks was greater before the introduction of tetanus antitoxin for prophylaxis and treatment; all the cases discussed here received the benefit of this treatment. Nevertheless, it is highly improbable that tetanus antitoxin diminishes the resistance of the vertebral column to stress.
5. Spinal deformity is seldom observed in fatal cases of tetanus, because the spines are rarely examined; also, with rare exceptions, changes are macroscopically invisible, although microscopic changes may be present which probably would have led later to a curvature under the burden of an upright posture.
6. Attention in recent years has been attracted more to the spinal column and to the changes produced in it by tetanus.

Although more frequent than suspected, the condition under discussion is nevertheless not often observed, even though follow-up examinations of tetanus patients from this viewpoint by Friedrich, Chasin, and Zukschwerdt and Axtmann showed varying degrees of kyphosis in thirty of the fifty-four patients whom they examined. However, such a method of examination has the disadvantage of not determining a definite causal and temporal relationship between the tetanus and the vertebral deformity.

The description of post-tetanic spinal deformity which follows is

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based on sixty-three cases, comprising almost all those appearing in the literature up to the present, as well as a hitherto unpublished case of Prof. Arnold Wittek's. The chief features of this deformity will be described and then compared with similar changes in the vertebral column which result from other causes; from these considerations, an attempt will be made to explain why kyphosis or gibbus formation follows some cases of tetanus and not others.

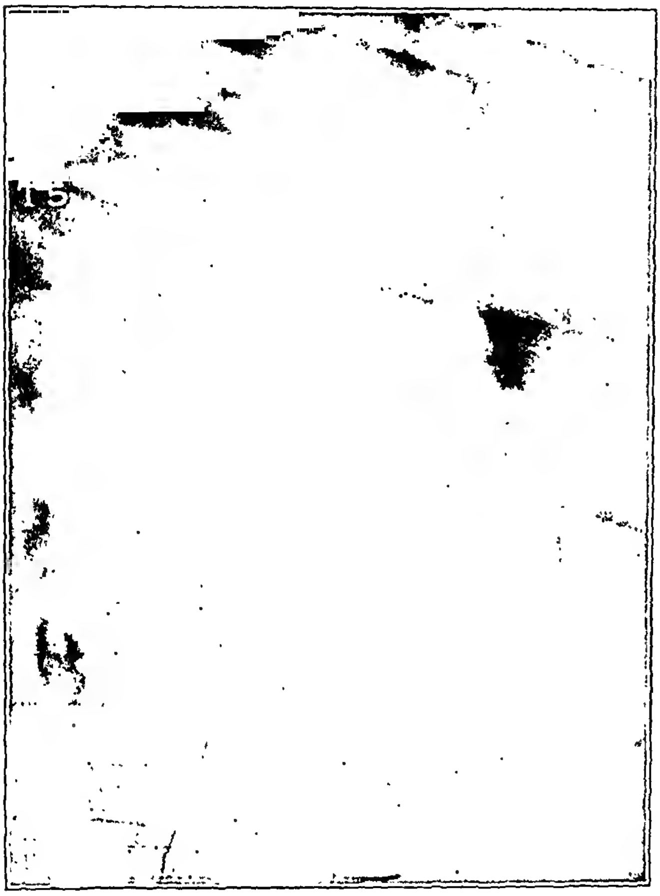

Fig. 1

Case 1. Lateral roentgenogram showing kyphosis in a fourteen-year-old boy, one month following recovery from tetanus.

CASE PRESENTATION

Case 1.* A boy, fourteen years of age, had had tetanus of three weeks' duration with opisthotonus and convulsions. Figure 1, a roentgenogram taken a month following his recovery, shows a pronounced anterior curvature, extending from the third thoracic to the eighth thoracic vertebra, with extreme flattening and sclerosis of the fourth and fifth thoracic vertebrae and indentation of the anterior surfaces. In the bodies of the fourth to tenth thoracic vertebrae, there is a curved indentation of the articular surfaces, chiefly of the upper surfaces, and, with the exception of the ninth and tenth thoracic vertebrae, in the posterior third of these surfaces. In some of the depressed regions, there is also a moderate sclerosis beneath the cartilaginous end plates. No treatment was instituted and an examination of the boy three months later showed a striking regression of the deformity with good mobility of the affected portion of the spine. Although the roentgenogram made at this time (Fig. 2) does not demonstrate all the vertebral bodies most affected, it does show an increase in height of the vertebrae involved in the kyphos, as well as a haziness and raggedness in outline of the lower thoracic vertebrae.

Case 2.** The patient was a boy, twelve years old, in whom kyphosis was first noticed immediately following an attack of tetanus. The roentgenogram (Fig. 3) taken six weeks after recovery from tetanus shows an abnormal anterior curvature of the thoracic spine from the fourth to the eighth vertebrae, with a marked anterior wedging of the fifth, sixth, and seventh vertebrae, in addition to sclerosis of the bodies and a haziness of outline. Slight anterior indentation is present here; this indentation results from

* This case has not been previously recorded.

** For permission to publish the roentgenograms of this case the author is indebted to Assistant Dr. Gerhard Haberler of Prof. Haas's *Universitäts-Ambulatorium für orthopädische Chirurgie* in Vienna. This case has also been presented by Gold [24].

the anterior displacement of the upper and lower portions of the body in compression fracture and may be exaggerated by the relative persistence of the infantile central cone defect of the vertebral body (Fig. 3, *T 9*). Also in the ninth thoracic vertebra, the crucial vertebra of juvenile kyphosis, is seen a localized anterior indentation as well as sclerosis of the upper end plate. The roentgenogram (Fig. 4) taken five years later, when the patient was seventeen years old, exhibits a striking reduction in the degree of the kyphosis. The sixth thoracic vertebra, most affected in the first roentgenogram, shows less recovery of height than the others; its upper and lower borders are thickened and wavy, as are those of most of the others shown in this film. In the roentgenogram taken five years later, however, there is not only a regression of the original curvature, but a new arc-like curvature in the lower thoracic spine, best observed by following the outline formed by the posterior surfaces of the seventh to the eleventh thoracic vertebrae. The upper and lower surfaces of the ninth, tenth, and eleventh thoracic vertebrae show sclerosed indentation in the centers, irregular excavation, and hazy, undulating contour. This is a typical picture of a late stage of juvenile or adolescent kyphosis, first emphasized as a clinical entity by Scheuermann in 1921. It is noteworthy that the brother of this patient, aged twenty-nine, exhibited the kyphos shown in Figure 5. One is inclined to attribute this to an adolescent kyphosis and to be reminded of the frequent familial incidence of this condition.

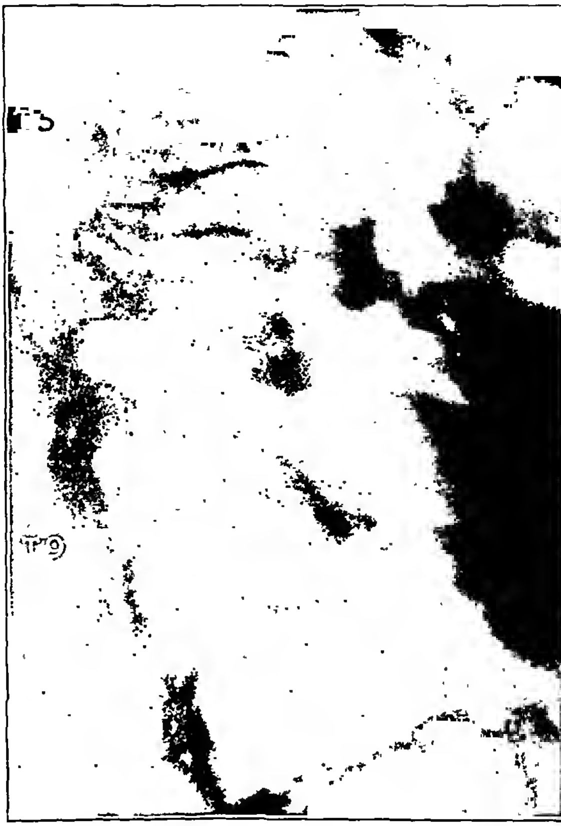

FIG. 2

Case 1. Three months later than Fig. 1.

CASE 3.* The patient, a boy of fourteen, noticed a continually increasing pigeon breast during the third week of convalescence from an attack of tetanus; this attack had lasted two weeks and was marked by opisthotonus and convulsions. Examination showed that a kyphos had developed subsequent to recovery. Prof. Leb's report of the first roentgenogram, taken six weeks after recovery, is as follows: "Fifth thoracic compressed to less than one-half of normal height; seventh and eighth thoracic, to two-thirds. Upper end plate of eighth thoracic indented. Epiphyses show a normally preserved bone nucleus. As a result of narrowing of the anterior vertebral borders and compression fractures of the middle thoracic vertebrae, a thoracic kyphos has been produced." The patient was suspended by the hands and a head sling, with the lower extremities resting on a horizontal support, and, after hanging twenty minutes in this position, he was placed

* This case was previously published by Kamniker merely from the standpoint of treatment.

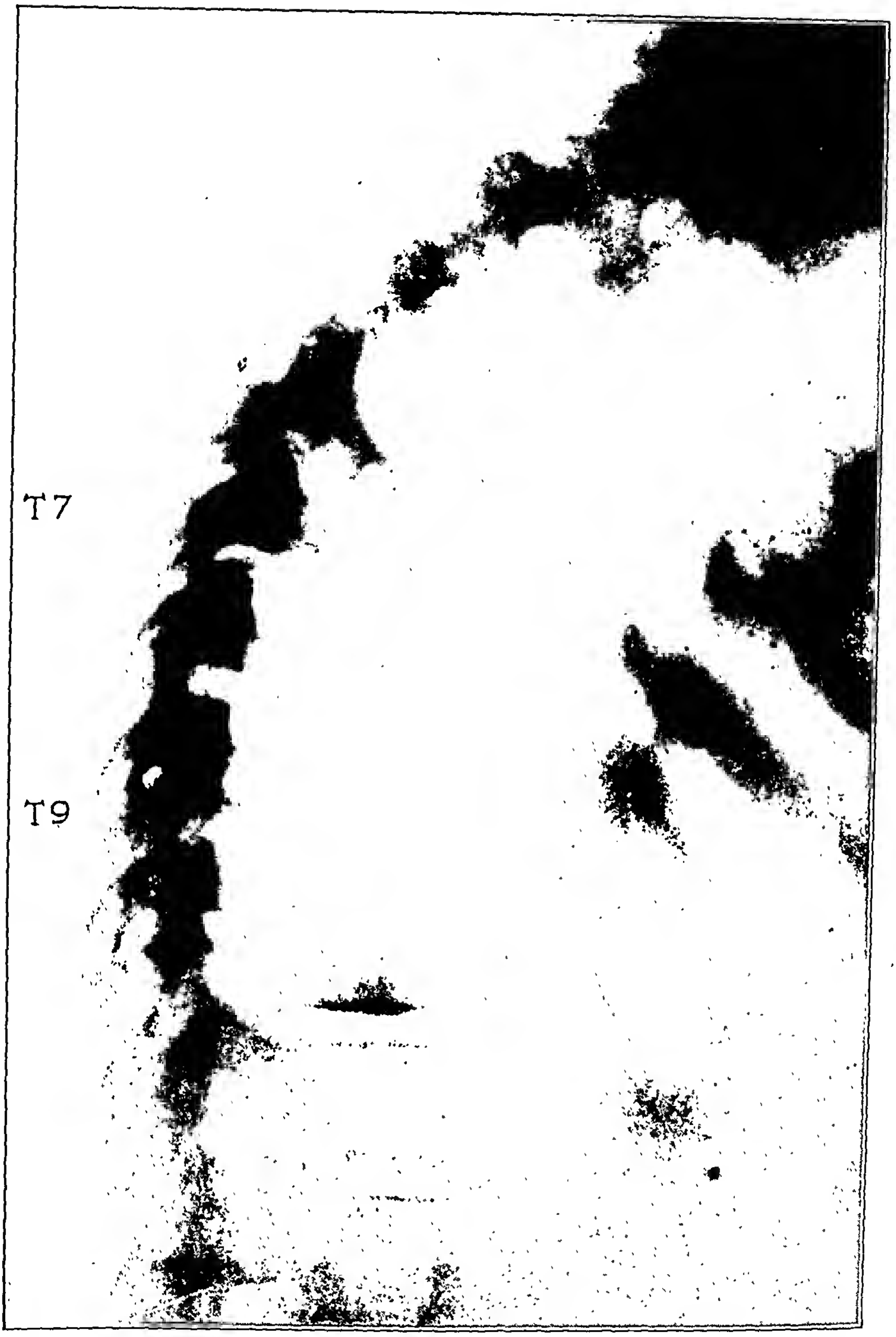

FIG. 3

Case 2. Lateral roentgenogram showing kyphosis in a twelve-year-old boy, six weeks following recovery from tetanus.

in a plaster corset, which was renewed twice by the same procedure during the next six months. Two months after the first roentgenogram, the one shown in Figure 6 was taken, and Prof. Leb reported: "Slight flattening of fifth thoracic; marked wedge formation of sixth to eighth thoracic, with a diminution in the height of these vertebrae. The upper articular cortex of ninth thoracic somewhat indented (beginning cartilage-node formation). Intervertebral spaces of normal height. Marginal epiphyses normally formed and applied. Moderate kyphosis of middle and lower thoracic spine." A

control picture, taken two months later, bears the following note: "The individual vertebral bodies are sharply outlined and only in the anterior parts of the fractured vertebrae is there an irregular outline with disturbed development of the marginal epiphyses." Here again there is the same irregularity of contour with a slight shifting of the original curvature from the middle or upper portion to the lower portion of the thoracic spine during a later stage of the deformity, in spite of corrective treatment. It is noteworthy that changes in the marginal epiphyses appeared only in roentgenograms taken five and one-half months following recovery from tetanus and four months after a roentgenogram showing them to be normal in spite of marked deformity of the vertebral bodies. Although all films were not available, Prof. Leb, the roentgenologist, informed the author that the roentgenograms of this spine, taken during the following two years, were typical of juvenile kyphosis.

FIG. 4

Case 2. Five years later than Fig. 3, when the patient was seventeen.

CASE REVIEW *

For the purpose of analysis, the number of cases becomes limited in one respect or another, because complete data are given in only a few reports, and even these do not answer all the questions one might ask. Thus the number of cases supplying statistics for one feature will differ from the number of those allowing adequate inspection of another feature. The individual case histories will not be repeated here, and tabulated statistics will be omitted in favor of graphs and of significant figures, with conclusions derived from them.

Nature of the Spinal Curvature

Out of sixty-three cases, a transient kyphosis of the thoracic vertebral column, present only during tetanic convulsions, was noticed in two

* Three cases were added following completion of this paper,—those reported by Randerath, Nagy, and Philippsberg. These are included in the statistical descriptions, but they are not represented in the graphs, although they support the conclusions derived from the graphs.

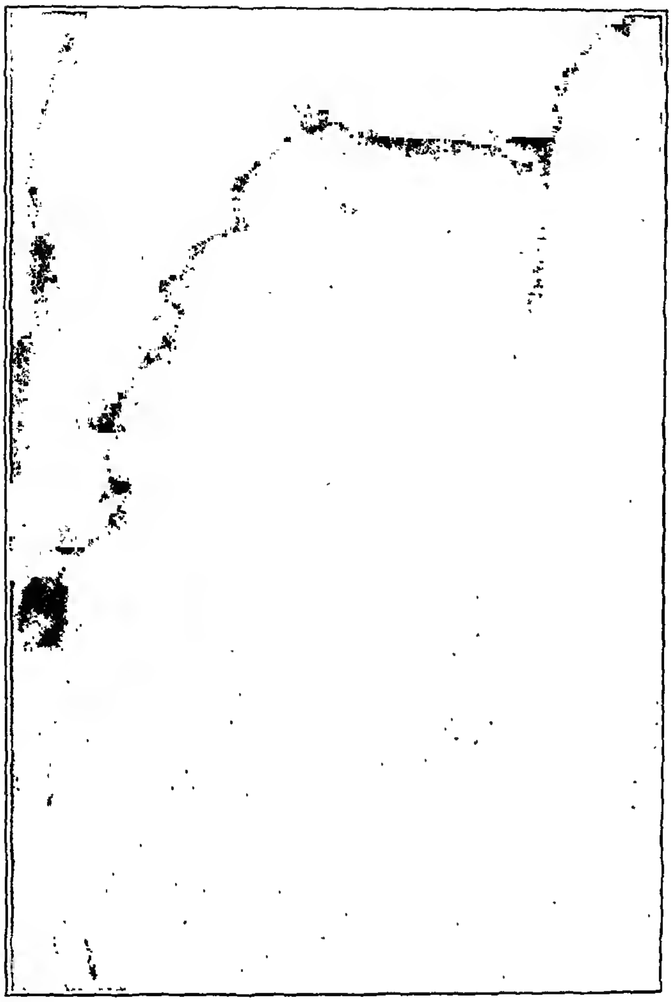

FIG. 5
Kyphotic spine of older brother of patient in Case 2.

infants and in one eight-year-old child. In five other cases, a fracture was regarded as probable in two, and as certain in three (but only from clinical examination). A fracture of one or two vertebral bodies was found at autopsy in four fatal cases of tetanus. Nine others were diagnosed roentgenographically, and two of these were associated with a pigeon breast, or pectus carinatum, which had developed during the convulsions. There were forty-two cases of kyphosis without definite fracture, fixed more or less in proportion to its degree, all with a compensatory lumbar lordosis; in eight of these there was an associated pigeon breast.

Level and Extent of Kyphosis or Fracture

Among thirty cases of kyphosis in which level and extent were described, the peak was recorded in twenty at the sixth thoracic vertebra, and in ten at the fifth thoracic vertebra. The extent varied from two or three thoracic vertebrae to five. In Figure 7, the number of times each vertebral body was affected in thirty cases of post-tetanic kyphosis is indicated by the unbroken line (Curve *1*), and in ten cases of fracture, by the dotted line (Curve *2*).

Distribution According to Age

Of the forty-five cases in which suitable data were given, thirty-two were cases of kyphosis without fracture, and thirteen were cases of fracture. Figure 8 is based on forty-one cases and shows that twenty-six cases occurred between the ages of nine and seventeen; then there was a sharp break in age frequency, and twelve cases were scattered between the ages of twenty and thirty-four. The relative incidence of fracture is seen to be twice as great in the adult group as in the group of younger or adolescent individuals. The cases not included in Figure 8 also contribute to the conclusions derived from this graph.

Sex

The proportion of male to female was thirty-two to ten, and in no case was a girl over seventeen years affected. The adult group was composed exclusively of men.

Symptoms Connected with the Deformity

There was usually some radiating back pain and tenderness over the affected vertebrae, rarely lasting more than a few weeks following recovery from tetanus. The movements of the back as a whole were free and painless when not limited by a residual tetanic rigidity of the muscles, and when the extent of the fixed kyphosis was not great.

Fig. 6

Case 3. Kyphosis in a fourteen-year-old boy, three months after recovery from tetanus.

Physical Background

Although in one case[72] there was a family history of tuberculosis, as well as a clinical suspicion of pulmonary disease with a pathologically proved caries of a finger bone, and although the two cases of fracture of the lumbar vertebrae were associated with gun-shot trauma and suppuration in the affected region, there was nothing in the other cases to suggest a background of disease or defect in the muscular system or skeleton, although most authors have sought diligently for such a background. Brunzel stated that tetanus produces spinal deformity chiefly in rachitic individuals, but there is no case evidence to support this; nor is there evidence that kyphosis preceded the attacks of tetanus in the cases recorded.

Type and Duration of Tetanus

In the younger patients, the time of incubation varied from five days to two weeks, and the average duration of the illness itself was three weeks; this does not include the exceptional case reported by Leube, in which intermittent attacks of rigidity and convulsions occurred over a

period of thirteen months, and where a kyphos with pigeon breast developed in the sixth month. Information on this point was given in eight of the twelve older cases. In six of these, the tetanus had an incubation period of from one to four months and the duration of the attack which, as in all cases, was accompanied by severe convulsions, was from one to three months. In all eight cases, the average period of incubation was seven weeks, and the average duration of the disease was six weeks. In several adult cases, in which the latent form of the disease occurred, a residual tetanic rigidity was noted to be present in the back muscles for some time following recovery. From a further comparison of the two age groups, it is seen that the tetanus required to bend or to break an adult spine had a duration approximately three times as great as that which produced similar changes in younger individuals.

Time Required for the Appearance of the Deformity

This figure is naturally subject to variations in accuracy of observation and in the time intervals of follow-up examination. The development of a kyphos or a gibbus was noticed in practically all of the younger group either during the attacks or immediately following recovery from them. In two of the eight adults for whom data are available on this point, spinal curvature was noticed at the time of recovery; in two others, six weeks later, and in four others, after one, one and one-half, two, and three years, respectively. It is apparent that the development of a kyphos or a gibbus requires a longer period of time in the adult group than in the younger group. One might like to observe that kyphosis immediately following tetanic convulsions in an adult should be produced by the fracture of a relatively brittle vertebral body, and that kyphosis of late development should be the result of the gradual bending of the spine after an initial injury over a greater period of time. Although the adult vertebral column has attained ossification and is more stable and brittle than the adolescent spine, and although it will later be shown that differences of this sort are fundamentally responsible for the division which has been made between adult and juvenile spinal deformities, an examination of the material fails to show that a fracture necessarily appears early and that a uniform kyphosis appears late. Furthermore, although we see kyphosis appearing in a few cases only after the lapse of months, we may not assume that a residual tetanic contraction of the musculature continues to act to produce this deformity, because, as will be pointed out later, the rigidity of those muscles which produce an increase in the normal thoracic anterior concavity would hardly escape clinical observation. Even though it is apparent that tetanus of longer duration and greater severity is necessary to produce anatomical alteration in the vertebral column of an adult than in that of a younger individual, we must assume that the initial damage to the spine ends with the recovery from tetanus, and that later changes are due to secondary processes in the vertebral bodies which are exposed to

the function of supporting the body in its carriage and muscular movements.

Four striking examples of such secondary changes may be cited. Chasin [12] described the case of an intelligent doctor, twenty-six years old, who developed trismus and convulsions nine days after an injury to his elbow. These lasted twenty-two days and the patient stated that during a convulsion he heard and felt a sharp crack in his back. At the time of discharge no deformity was observed. A year later the patient again entered the hospital because of a postscarlatinal nephritis, and a moderate kyphosis was observed in the upper thoracic spine. Roentgenographic examination showed a confluent destruction of the fifth, sixth, and seventh thoracic vertebrae without paravertebral abscess or other evidence of tuberculosis; of the fifth thoracic vertebra there were only splintered traces. Zukschwerdt and Axtmann described a case in which the spinal column was roentgenographically normal following an attack of

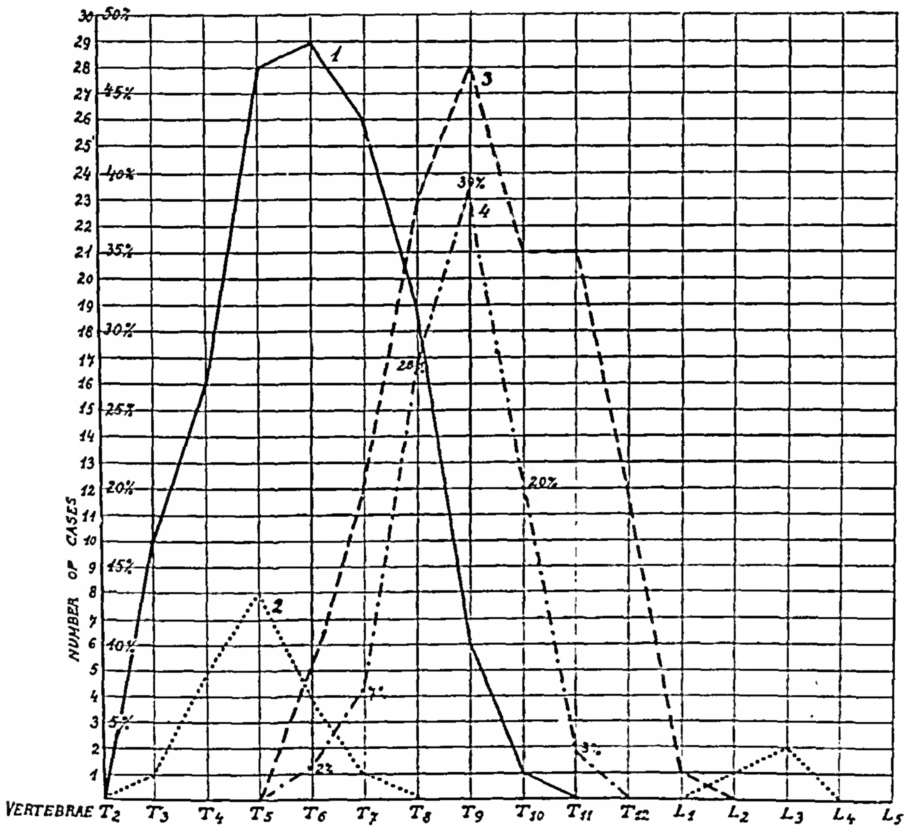

Fig. 7

Relative incidence of affected vertebrae.

Unbroken line (1) = Thirty cases of post-tetanic kyphosis.
Dotted line (2) = Ten cases of post-tetanic fracture.
Interrupted line (3) = Thirty cases of juvenile kyphosis.
Dotted and broken line (4) = Percentage incidence of vertebrae forming the apex of the normal thoracic curvature.

tetanus. Six months later, a collapse of three vertebral bodies was found. In another case, three bodies were seen to be compressed one year following recovery. A subsequent roentgenogram, taken three months later, showed a flattening of two more vertebrae. A fourth case, that of a ten-year-old boy, revealed a high-grade compression of three vertebral bodies six months following recovery; six months later the number had increased to five or six.

Nature of the Changes in the Vertebral Bodies Themselves

A good description of these is found in twenty-two cases of kyphosis and in ten cases of fracture. In four fatal cases of tetanus, fresh fractures of vertebral bodies were demonstrated anatomically; apart from mechanical disturbance of structure, the vertebrae were normal. We shall return to a detailed consideration of these later. On

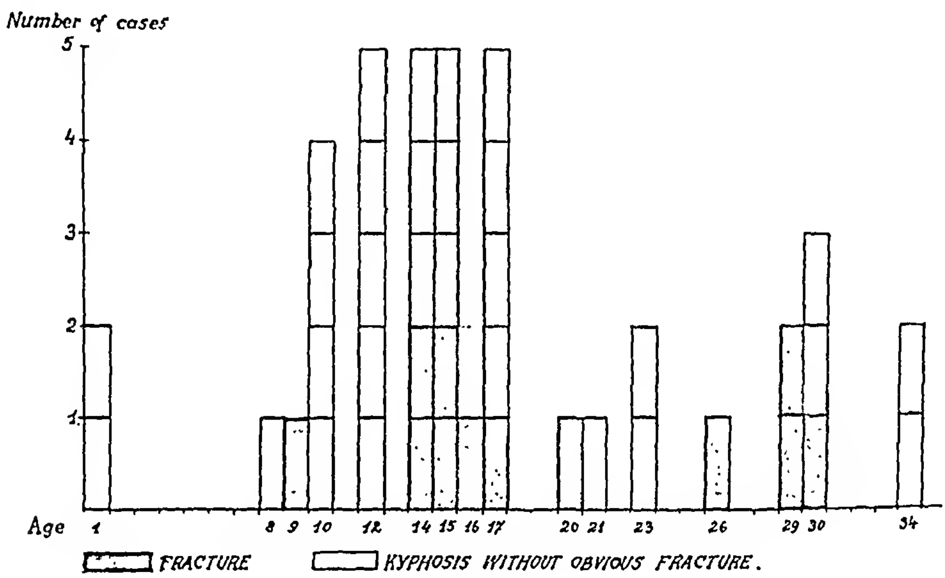

Fig. 8

Age incidence of patients with post-tetanic spinal deformity.

the other hand, the roentgenographic determination of a fracture is less certain. A fragmentation of the bony structure extending through the periphery of the shadow is certain evidence of fracture. A displacement of one portion of the body against another part in a sagittal or frontal direction also demonstrates a fracture. Flattening in a vertical direction or isolated wedge formation associated with a continuous line of increased density in the interior of the body, even in the presence of an intact outline, is suggestive of a break in the spongiosa. In cases of kyphosis in many young individuals [30], the indentation of the anterior surface in the compressed bodies may be regarded more as evidence of a predisposition to rather than as a result of fracture. Another criterion is the formation of a sharp angle at the junction of two lines which are drawn through the longitudinal axes of successive vertebral bodies in a lateral view of the spine; this, however, can apply only to a sharp break in contour. The

usual kyphoses, such as the postural and senile types, are of gradual development and do not give occasion for the determination of whether or not a microscopic fracture may play a part. In the kyphoses of rickets, tuberculosis, multiple myeloma, tumor metastases, Paget's disease, ostitis fibrosa generalisata, etc., if fracture occurs there is an evident pathological basis. However, it is far more difficult for the roentgenologist than for the pathologist to separate a true fracture, associated with a single collapse and shattering of the bone trabeculae and hemorrhages, from a change in form of the vertebral body, associated with a mere gradual transformation of the bone tissue. Where a very evident fracture of the spine occurs, the action of the force is of such short duration that, unless a fracture occurs at the time, the vertebral column usually escapes without injury; however, such trauma can sometimes lead to progressive disintegration of the cancellous bone, as in Kümmell's disease, or to progressive vertebral atrophy. It is one of the striking characteristics of the spinal deformities following tetanus that a field is offered where kyphosis and fracture result from the same cause, and that the border-line between a bend and a break in the vertebral column is here far more transitional than in the other conditions just mentioned. There is little doubt that fractures of slight degree in adjacent vertebral bodies can produce simply a uniform exaggeration of the normal anterior curvature of the thoracic vertebral column.

To turn to the roentgenographic reports of twenty-nine cases: of the twenty-two cases diagnosed simply as kyphosis, a wedging or flattening of the involved bodies was described in all except four; these four comprised cases in which the patients were between the ages of twenty-three and twenty-eight, in which the time interval following tetanus was not given, and in which a roentgenographic kyphosis existed without change in the shape of the vertebral bodies and without diminution in height of the intervertebral spaces. In sixteen cases, there was an abnormal indentation of the upper or lower end plates, usually not pointed out by the authors, but observable in the roentgenograms especially of the spines of younger individuals, where the superior and inferior contours are normally either straight or only slightly convex. In six of these there was a line of marked sclerosis or condensation of the spongiosa just beneath the end plate. In four cases, there was a notching of the anterior surfaces of the affected bodies; the ages of these four patients were ten, ten, twelve, and fourteen years, respectively. Of the cases of fracture, apart from those determined at autopsy, one showed a chipping-off of the anterior superior corners of the seventh, eighth, and ninth thoracic vertebrae to an extent and clarity that exclude confusion with delayed or absent union of the ossifying cartilaginous epiphysis. Three others of this group of roentgenographically diagnosed fractures gave a flattening and fragmentation of one or more vertebral bodies,—two showed an acute wedge formation of two adjacent bodies, in one of which there was an obliteration, and in another a narrowing of the intervertebral space; and one

showed a wedge formation with indentation of the end plates. A further case showed clinically a sharp gibbus with its crest at the level of the third lumbar vertebra. In a number of cases of both kyphosis and fracture, there was some atrophy of the affected vertebrae.

Subsequent Course of the Vertebral Deformity

Friedrich examined three cases of acute kyphosis following tetanus incurred during the War, in which examination was made eleven, seven, and five years, respectively, after the primary illness. The patients were probably adult at the time of the onset of tetanus, although the ages were not given. Zukschwerdt and Axtmann described four individuals between the ages of twenty-three and twenty-eight, showing moderate kyphosis in the region of the fourth to the ninth thoracic vertebrae, who at one time or another (not recorded) had had tetanus. Neither the age at which the tetanus occurred nor the time elapsing after recovery from it was given. Such reports indicate only that the curvature was probably the result of the tetanus and that later it did not entirely disappear. Becher's case of post-tetanic kyphosis, occurring in a man, twenty-three years of age, was examined two years later by Spieth, who found no improvement in deformity at that time. Another case of a man of the same age showed little improvement at a later date. Kyphosis in a sixteen-year-old youth disappeared a month following recovery from tetanus. A twelve-year-old girl, a patient of Ehrlacher's [17], exhibited no improvement in the kyphosis, although Ehrlacher succeeded in obtaining complete reduction of a kyphos, involving the third to the ninth thoracic vertebrae in a ten-year-old boy, by means of successive bracing of a Calot reduction cast with felt pads. A case already mentioned is that of a boy of ten years who had a marked kyphos, with flattening, wedging, indentation, and sclerosis of the bodies of five thoracic vertebrae one year after recovery. Because of radiating back pain for weeks following the attack of tetanus, the patient wore a plaster jacket for six months. Five years later, the kyphos had entirely disappeared, and a lateral roentgenogram at that time showed an almost complete return of height of the affected vertebrae, although irregularities in the upper and lower surfaces, sclerosis, and spotted and streaked areas of increased density were still present. An increase of deformity during the first year limits the possibility of benefit from the plaster jacket. The nine-year-old girl with fractures of the second and third lumbar vertebrae retained the gibbus three years later, as well as a hyperreflexia of one leg. Two cases of tetanus neonatorum were described in which the convulsions produced a kyphoscoliotic distortion of the spine which disappeared after the convulsions. Bakay recorded a similar occurrence in a child of eight years.

In no roentgenograms of an adult case of post-tetanic kyphosis has the author been able to find a haziness of the upper and lower margins of the vertebral bodies with an undulating irregularity and spotty sclerosis in these areas; in adults, the changes are more linear and sharply

outlined. The greatest inequality in central translucency and opacity is also found in the cases of younger patients.

SUMMARY OF FEATURES OF POST-TETANIC SPINAL DEFORMITY

1. Spinal deformity following tetanus assumes the form, in most cases, of a uniformly curved, often rigid kyphos in the upper or middle thoracic vertebral column; in a limited number of cases a fracture was demonstrated pathologically or roentgenographically at this level, and in two cases there was a compression fracture in the lumbar region.
2. Twenty-six cases of anatomical deformity occurred between the ages of nine and seventeen, of which seven were cases of fracture; only twelve of the cases occurred in adults, approximately one-half of which were cases of definite fracture.
3. In each case, the patient's physique was almost without exception that of an otherwise normal, healthy individual.
4. In the adolescent group, the attack of tetanus was of about three weeks' duration, and the incubation period was from five days to two weeks; whereas the adult group was characterized by a latent tetanus with an average incubation period of seven weeks for all cases, and a duration of the tetanus itself of six weeks.
5. In most of the adult cases, the deformity was noticed only after the lapse of a long period of time.
6. The changes in the vertebral bodies themselves consisted of flattening and wedging of the affected vertebrae, with a particular blurring, thickening, and indentation of the superior and inferior surfaces in the younger patients.
7. The cases of post-tetanic kyphosis showed a marked tendency toward regression of the deformity in younger individuals, and in the three cases, the roentgenograms of which are presented, this regression was accompanied by a slight increase in thoracic curvature below the original deformity, with changes in outline further characteristic of juvenile kyphosis.

From this survey, one gains the impression that the adult spine is more resistant to tetanus and less plastic than the adolescent spine; also, that if regressive changes do take place in adults, they are not accompanied by the same changes in the end-plate region seen in the incompletely developed vertebral column of adolescent individuals.

THE MECHANISM OF THE SPINAL DEFORMITY

Distinctive Location of the Curvature

The spinal deformity following tetanus is typically a gibbus or a kyphos in the upper thoracic spine, affecting chiefly from four to five vertebrae, with a well-defined crest usually at the level of the sixth thoracic vertebra (Fig. 7). In many respects, it is comparable to a traumatic gibbus or to kyphosis dorsalis adolescentium,—in extent, in

degree, and in the time required for development, as well as in the structural alterations seen in the roentgenograms of the vertebral bodies. Schmorl and Junghanns (page 140)[68] mention the fact that a traumatic kyphosis is often difficult to distinguish from juvenile kyphosis in a roentgenogram. Where fracture has taken place, one sees fragments and depressions most often on the upper edges of the anterior surfaces of the bodies, as in the common compression fractures of the spine[25, 59, 60]. However, the level of fracture is different from that seen in traumatic vertebral compression. From five different statistical tables[25, 68] the following order of frequency is derived from vertebral bodies affected by a compression fracture: (1) twelfth thoracic; (2) first lumbar; (3) sixth cervical; (4) fifth cervical; (5) seventh cervical and second lumbar; (6) eleventh thoracic; (7) third lumbar; (8) fourth lumbar; (9) tenth thoracic; (10) fourth cervical and sixth thoracic. In the usual compression fractures of the spine, the mobile junctures of the three main portions are chiefly affected, in sharp contrast to the middle portion of the thoracic spine, which is broken or bent in almost every case of post-tetanic spinal deformity. Nor does the level in the case of tetanus correspond to an exaggeration of the normal, statically conditioned thoracic curvature. Figure 7, Curve *4*, showing the relative frequency of the apical vertebra in the normal thoracic spine, gives a curve lower than that of the tetanus curvature, but corresponding exactly to the level of that in juvenile kyphosis (Curve *3*).

Tetanic Convulsion

Muscle contractions and convulsions in tetanus may have only a local extent; they may be unilateral, or they may produce an acute anteflexion of the trunk, but these are exceptions. Tetanus which produces spinal deformity is generally of the "opisthotonus" type, with bilateral tonic and clonic contractions of the trunk muscles from neck to hips. The neck is retracted, the buttocks are drawn backward on the spine, and there is convulsive fixation of the thorax in the expiratory position, often with a transient depression on both sides of the sternum. A rigidity of the abdominal muscles may be the first to appear. The neck muscles stand out and the pectorals and the latissimi dorsi are contracted. The presence of an exaggerated lumbar lordosis is emphasized by unsuccessful attempts to make a lumbar puncture during the acute stage[1, 4, 42]. A retraction of the neck with lordosis of the cervical spine is evident and causes clinicians to speak of opisthotonus and to question that a thoracic kyphosis could result from it. Ehrlacher and Bakay have both seen transient convulsive kyphosis and kyphoscoliosis in infantile tetanus. Also from the nature and development of tetanic kyphosis, it is obvious that the typical tetanic convulsion bends the thoracic spine anteriorly. A slight scoliotic component is often present.

Rôle of the Spinal Extensors

The opinion that a contraction of the spinal extensors alone could

lead to an increase in the normal thoracic anterior concavity between the cervical and lumbar anterior convexities is contradicted by the fact that normal physiological contraction of the back muscles bends the entire spine backward, and by the fact that the muscular ridges of all spinal extensors lie on the posterior surfaces of the transverse processes. Even where an abnormal thoracic kyphosis is already present, these spinal extensors could not possibly fall into line with an anterior thoracic concavity, but remain always posterior to the longitudinal axis of the vertebral bodies[28]. The only members of the spinal muscles contributing to an anteflexion of the spine are the serrati posteriores, whose superior division runs from the transverse processes of the sixth cervical to the second thoracic vertebrae to the second to the fifth ribs, and whose lower division lies similarly between the transverse processes of the eleventh thoracic to the third lumbar vertebrae and the ninth to the twelfth ribs (Fig. 9, *3* and *4*). Contraction of these muscles favors a thoracic kyphosis. The remaining spinal muscles belong to the erector group (Fig. 9, *13*). In contrast to the great strength of this group in the cervical and lumbar regions is its marked weakness over the thoracic spine. The short muscles of the medial tract, the interspinales, are attached between the spinous processes, but in the thoracic region are insignificant and mostly absent. The attachments of the remaining muscles of this group bridge the greatest gaps between spinous and transverse processes in the thoracic spine; and in this region the ligamentum supraspinale is especially weak. In general, the fourth, fifth, sixth, and seventh thoracic vertebrae, the region of the usual tetanic gibbus or kyphos, are least covered by the spinal erectors and least resistant to a contraction of the anterior trunk musculature.

Rôle of the Spinal Flexors

It has already been stated that certain spinal muscles aid the forward bending of the upper trunk. When one thinks of the round-shouldered boxer, the hunching position of the back in the downward movement of the crawl stroke in swimming, and the convulsive forward bending of the body in coughing, one sees the action of certain muscle chains (Fig. 9) in transmitting the contraction of the anterior body musculature to the vertebral column. Spitzy cited the condition of deficient body constitution in which there are defective posture and increased thoracic kyphosis caused by hyperactivity of the respiratory muscles. Edelstein presented the case of a fourteen-year-old boy, in whom a well-developed adolescent kyphos appeared during a two-month siege of bronchopneumonia. In this case, one can exclude static trauma during the appearance of the curvature, but the flattened vertebrae were the sixth, seventh, and eighth thoracic vertebrae, comparable to the "dynamic" level in tetanus and contrasted with the usual "static" level in juvenile kyphosis. This suggests that coughing during the illness may have provided the contributing mechanical factor.

One of the muscle chains mentioned is formed by the latissimus dorsi and the pectoral muscles (Fig. 9, *7* and *5*), which draw the lower spine and upper thorax together toward a common point on the upper humerus which is fixed in the shoulder joint, and by the trapezius and the deltoid muscles. The upper ribs and spine are drawn together by the second chain (Fig. 9, *6*), which is composed of the serratus anterior, the rhomboidei, and the levator scapulae. The action of this chain is seen in the winged scapula found with the pigeon breast, often associated with post-tetanic spinal deformity. A third chain is seen in the diaphragmatic attachments between the upper lumbar vertebrae and the inner surfaces of the lower ribs and sternum (Fig. 9, *10*); expiratory contraction of the diaphragm draws the lumbar spine and the lower ribs toward each other and can also contribute to the production of a pigeon breast. Three other groups also contribute to this upward bending of the lower spine: (1) the obliquus externus abdominis and the obliquus internus abdominis (Fig. 9, *8*), inserted into the lower ribs and the linea alba and originating from the lumbothoracic ligament, the iliac crest, and the inguinal ligament; (2) the quadratus lumborum (Fig. 9, *11*), attaching the iliac crest and the iliolumbar ligament to the lumbar vertebrae and the lower border of the twelfth rib; and (3) the iliopsoas (Fig. 9, *9*), connecting the lumbar vertebrae with the iliac fossa and the lesser trochanter of the femur. The diaphragm and the last three groups tend to flatten out the lumbar lordosis and even to cause a lumbar kyphosis in the absence of predominating contraction of the spinal extensors and of the flexors of the upper trunk which would cause the spine to give at a higher level. In the two cases [8] in which a tetanic fracture of the second and third lumbar vertebrae occurred, pieces of shot were present in this region, and, in addition to the factors of nephrectomy and suppuration in the younger patient, could have given rise to a particularly severe local tetanus of the muscles just mentioned. Hammer [29] reported a case of tetanus localized in the muscles innervated by the left lumbar plexus.

Not only does the sternum comprise a fixed point anterior to the spine toward which the upper and lower muscle chains can bend the thoracic spine, but the powerful chain of anterior trunk muscles exerts a force of primary importance. This action begins in the sternocleidomastoidei (Fig. 9, *1*), which produce a retraction of the neck when acting simultaneously and when the head has already been tipped backward. These and the scaleni (Fig. 9, *2*) fix the upper end of the sternum and the thoracic cage to the mastoid processes and the cervical spine, and the contracting force becomes transmitted over the thorax through the sternum, and the pectoral, intercostal, subcostal, and transversus thoracis muscles, and the ribs, to the recti abdominis (Fig. 9, *12*), which in turn anchor the chain to the pubic bones and enable it to exert its tremendous leverage on the spine, which is far greater than that of the spinal extensors because of its position far anterior to the vertebral column. This chain operates also through the leverage arm of the ribs, which, according to Braus, exerts a

Fig. 9

Diagrammatic representation of muscle chains acting in tetanus to produce spinal deformity:

1 = sternocleidomastoideus;
2 = scaleni;
3 = serratus posterior superior;
4 = serratus posterior inferior;
5 = pectoralis major and pectoralis minor;
6 = serratus anterior, rhomboidei, levator scapulae;
7 = latissimus dorsi;
8 = obliquus externus abdominis and obliquus internus abdominis;
9 = iliopsoas, psoas major, and psoas minor;
10 = diaphragma;
11 = quadratus lumborum;
12 = rectus abdominis;
13 = extensores spinalis dorsi.

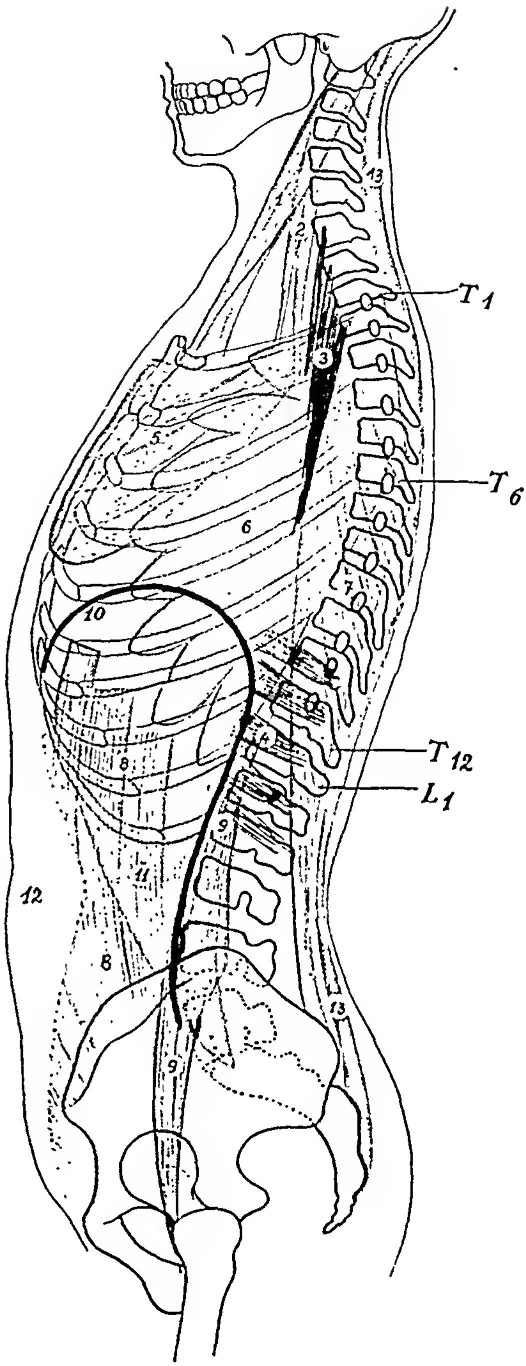

Fig. 9

leverage action on the vertebral column beyond the limits of movement imposed by the vertebral joints themselves.

Scoliosis is relatively insignificant in post-tetanic spinal deformity, because the muscle contractions are almost always bilaterally symmetrical and bend the trunk in an anteroposterior plane. The spine is also far more resistant to a traumatic scoliosis induced by muscle contraction, because the muscles which might produce this have far less leverage, and the resistance of the vertebral column to rotation and lateral bending in such a circumstance is resisted by the ribs and intercostal muscles and ligaments, as well as by the interlocking of the articular processes to prevent lateral motion, especially in the thoracic spine. As Müller[48] has pointed out, in all the processes which lead to a formation of wedge-shaped and flat vertebrae, we find repeatedly sagittal curvatures, whereas scoliosis represents the deformity of particularly resistant vertebral bodies.

Permanent deformity is not the result of latent tetanus or of continued muscle rigidity, but of change in form of the vertebral bodies. When fixation of the kyphos occurs, it is the result of changes in the intervertebral discs.

Thus the typical post-tetanic spinal deformity is an anterior bending of the thoracic spine, with the apex of the bend at the sixth thoracic vertebra, and is caused by a predominating contraction of the anterior trunk musculature, which produces an anteflexion of the spine at this point.

RESISTANCE OF ADULT VERTEBRAE TO THE BENDING FORCE

Indirect Vertebral Fracture

It is well known that muscle action alone can break a bone, and cases of localized tetanus have been known to cause dislocation of the elbow or of the shoulder [70], as well as fracture of the femoral neck [2] and of the forearm [81]. However, fracture of a vertebral body by muscle action is practically unknown, except in tetanus, although this has been reported to have occurred in breeding stallions. If one makes use of the theory of Radmann to explain the mechanism of spinal compression fractures as the result of muscle action incited by external trauma, the susceptibility of the vertebral bodies to fracture by muscle action would be more apparent. According to this theory, the force of a jarring or bending fracture of the spine is not transmitted simply in a vertical direction from one body to another, but its horizontal and vertical components are resisted by a third, represented by a sudden tension occurring in muscles fixed at a point anterior to the spine and contracting reflexly. The contraction of these muscles compresses the anterior surfaces of the bodies in a mechanism similar to that of the tetanic curving of the thoracic spine anteriorly.

It has been shown that the bending force in tetanus acts to produce compression of the anterior portions of the vertebral bodies; this is apparent also from the nature of the deformity. There is still a question, however, as to the possibility of this occurrence in normal vertebral bodies, also as to whether they are defective or incur a toxic damage through the disease of tetanus apart from the mechanical injury. Although occasional authors have found evidence of a disease process in or near the vertebrae preceding the attack of tetanus, it has been generally impossible to find such a predisposing condition. Before taking up the question of developmental defects in the juvenile or adolescent spine which may provide such a background, we may consider the physical and pathological changes occurring through pressure injury to a normal adult vertebra, and the damage which vertebral bodies might incur through tetanus apart from the convulsive trauma.

Physical Changes Induced by Trauma

Messerer [16] and others have found weights of from 200 to 425 kilograms necessary to alter the shape of adult thoracic and lumbar vertebral bodies. Göcke found that weights up to 480 kilograms did not alter the

form of a vertebral body, but, through condensation and increased brittleness of the spongiosa, diminished the resistance to compression and increased the plasticity of the vertebral bodies. Trip-hammer blows in rhythmic succession reduced the elasticity of the bone after a certain time, so that the transient elastic flattening, which at first occurred with each blow, recovered less and less, and the vertebra became brittle and lost its initial resistance to sudden pressure. This corresponds to Lange's experiment (page 20)[47], in which temporary elastic flattening of a vertebral body occurred when pressure up to a certain amount was applied, but beyond this point a lasting deformity was produced by pressure. The tenth thoracic vertebra of a man who was killed by a fall from a five-story building showed less resistance to stress than the corresponding vertebra of a child, although no anatomical changes were present. This is analogous to the loss of temper in iron through hammering and is a physical explanation for diminished resistance of the vertebral body through transgression of the limit of elasticity without initial fracture of the spongiosa.

According to Fick, the fifth thoracic vertebra is the weakest in the entire spine.

The foregoing shows a remarkable resistance of the individual vertebral bodies to force which acts on them in a vertical direction, but it does not account for the occurrence of compression fractures as the result of relatively slight trauma; nor does it consider the impact resulting from the suddenness with which a lesser force might affect the vertebral body. The muscle contraction which causes a vertebral compression is a force that we cannot estimate, nor do we know the resistance of a vertebral body to such a force; and the leverage which is transmitted by the ribs and in the bending of the spine on itself has not yet been measured.

Pathological Changes Induced by Trauma

Immediate

A definite description of anatomical changes induced in vertebral bodies by tetanic convulsions has been made in only two cases. Because of the rarity of such a description, the two cases will be repeated here:

Case of Eberstadt. The patient was a soldier, twenty-nine years old. Two months following shrapnel injury to the elbow, there developed tremor, stiff gait, bilateral clonus, and Babinski reactions. A month later, the patient suffered back pain and convulsions, with bulging of the thoracic cage and prominence of the thoracic spine. Increasing gibbus formation was noted. Roentgenographic examination revealed collapse of the fourth and fifth thoracic vertebrae without localized defect. The patient died in convulsions four months after injury. Autopsy disclosed compression and flattening of the third and fourth thoracic vertebrae. The microscopic report was as follows: "In the affected vertebral bodies, numerous shattered, broken, and collapsed bone trabeculae, which comprise a rather disordered group. In many places, the medullary cavity is replaced by an oedematous vascular fibrillar marrow, which contains some plasma cells and small round cells with much protoplasm. Limited new bone formation with irregular calcification. No evidence of a specific process. Diminished calcium content."

This happens to be the first pathological report of a spinal fracture caused by tetanus.

Later, in 1926, Bäcker published a similar report as the first of its kind. That he described the preceding report as the expression of an osteomyelitis infectiosa, originating in a suppurating gun-shot wound of the elbow, is merely an interesting commentary on the personal factor which so often presents itself in the literature.

CASE OF BÄCKER. A boy, fifteen years old, suffered violent tetanic convulsions following foot injury. Convulsive lumbar lordosis prevented spinal puncture. The patient died two days following the onset. The autopsy report (Schmorl) follows: "Hemorrhage in connective tissue in vicinity of third to sixth thoracic, extending into the posterior mediastinum. Flattening of fourth and fifth thoracic. Extravasation of blood in the bodies of third to sixth thoracic. In profile section: bony portion of fifth thoracic separated from the overlying intervertebral disc by hemorrhage. Fifth thoracic compressed, sixth thoracic somewhat less so, spongiosa strikingly pale and crushed. Fourth thoracic moderately wedge-shaped, spongiosa likewise condensed and pale. Third thoracic only slightly so, and spongiosa crushed and pale only in the lower half.* Intervertebral disc between fourth and fifth thoracic infiltrated with blood. Fifth thoracic projects into the spinal canal. Ecchymosis between dura and posterior surface of vertebral body at this point, as well as a smaller ecchymosis between dura and arachnoid; at this level, meninges and cord oedematous. Microscopically: apart from the mechanical disorder, completely intact bone."

A third case of pathologically verified post-tetanic fracture was added by Randerath in 1936, in which a photograph of the sagittal section of the affected vertebrae showed multiple horizontal fractures, entirely fresh and showing no reaction, in the bodies of the third to the fifth thoracic vertebrae, especially in the fifth thoracic vertebra.

A fourth case was mentioned by Scharsich, who merely stated that a post-tetanic vertebral fracture was pathologically verified.

Delayed

Subsequent changes in the spine can be accounted for by the following analogy: Microscopic callus formation, with infraction and displacement of bone trabeculae, and minute hemorrhages in the vertebral bodies, are occasionally incidental autopsy findings. A more extensive form of this is found in definite vertebral fractures when death occurs shortly after the fracture. Schmorl has described it as follows: "unexpectedly extensive necrosis of the marrow cavity and bone trabeculae, which reaches into the bone tissue far from the line of fracture; this necrosis does not always coincide with the hemorrhagic shattering of the medullary space, but also occurs entirely separate from this". Schmidt described an example of this type in a vertebral body which had retained its form without an alteration that would have been roentgenographically visible. Death was caused in this case by fracture of two thoracic vertebrae. The changes described were found in a third. In another case of Schmorl's, death occurred on the eighth day as a result of fracture of the eighth tho-

* This topographical restriction speaks further for a purely mechanical causation.

racic vertebra. At autopsy, there was found an almost total necrosis of the fourth thoracic vertebra, although little more than the fatal fracture was found in the eighth thoracic vertebra. Schmidt regarded this as an atrophy of bone tissue, which took place not only under the influence of the organization of necrotic hemorrhagic areas, but in the center of these, separated from the activity of living tissue. He blamed the extent of atrophy on the hemorrhagic extravasation and raised the question of the relation of this to traumatic bone cysts and to bone changes in hemophilic joints. Schmidt also described a notable case in which a similar process occurred gradually in several thoracic vertebrae with no clinical trace of trauma. Here hemorrhage and necrosis were present even in bodies which had not lost their contours.

Recovery from such a condition can be associated with callus formation, and it is evident that one here approaches the entity of Kümmell's disease, which is connected not only with an initial external trauma, but with a later continual static trauma. Clinical and pathological analogies can be found in the "march fracture" of the second metatarsal, Köhler's disease of the tarsal navicular, malacia of the os lunatum, etc. The subject of pathological changes following vertebral fractures has been introduced here because they can account for a number of conditions in the spine following tetanus convulsions, whose cause might otherwise be sought in a preceding pathological defect. However, as Schmorl and Junghanns (page 79)[68] have pointed out, an old spondylitis infectiosa could be responsible for a wedge shape or fracture at autopsy, at a time when the original cause was no longer to be seen under the microscope.

Thus, from physical and pathological standpoints, where even a slight change has taken place in a vertebral body without alteration in form, the affected bone is more exposed to damage by the normal daily burden. Where a change in shape has already taken place, the weakened link or bent portion throws the entire chain into static decompensation, and a more definite basis is provided for later changes.

The Contributory Effect of Tetanus Infection

Various authors have spoken vaguely of a possible effect of tetanus toxin or even of the bacilli themselves on the vertebrae. This possibility is to be considered in the two rare examples of tetanic fracture of lumbar vertebrae, already referred to. The possibility of local circulatory disturbance has also been mentioned.

Krinitzki reported that he had produced hypocalcaemia by the injection of tetanus toxin in experimental animals, with a rise of blood potassium in severe cases. Although such a determination may have more value as an indicator for therapy, it could, in combination with the acidosis of tetanus, lead to a drain of the bone-calcium store, which is most labile, and which is the first to be affected in the bones of the vertebral column, particularly in young individuals. Moffatt has demonstrated exaggerated anteroposterior curves and the ease with which com-

pression fractures of the spine occur in nutritional calcium deficiency. He observed that the absence of bony condensation was most marked in the upper and lower margins of the individual vertebral bodies where condensation would otherwise occur as a reaction to the indentation of the elastic nucleus pulposus. Calcium deficiency produces a defect in growing bones in the zone of preparatory calcification, with secondary disturbance in vascularization and absorption of cartilage, and broadening and irregularity of the epiphyseal line (page 83) [47]. This is to be kept in mind in the later consideration of changes occurring in these parts of the vertebral body in children and in adolescents.

The conclusion to be drawn from the foregoing is that the apparently normal adult vertebral column is susceptible to gross or to microscopic compression fractures under the influence of tetanus and tetanic convulsions. This would seem to answer at once the predominance of vertebral changes following tetanus in younger individuals whose spines are less resistant than those of adults, even though their musculature may be correspondingly less well developed. Nevertheless, the muscle force acting on the spine is something we can judge only approximately and we cannot take the extent of damage to the vertebral column as the criterion of this muscle force when a vast number of severe attacks, even those ending in death, do not cause spinal curvature, and when others of lesser degree can produce a deformity. The rarity of post-tetanic spinal deformity and its relatively high incidence in adolescents are explicable neither on a muscular basis nor on the age incidence of tetanus in general.

The basis of weakness in the adolescent spine is rather to be sought in an exaggerated speed of endochondral ossification occurring in the vertebral metaphysis at this time, in which ossification lags behind a predominating growth of columnar cartilage. This will be dealt with in a further paper, but the view that the factors which expose the spine to juvenile kyphosis and post-tetanic spinal deformity are similar is supported by the comparable natures of these two conditions.

POST-TETANIC SPINAL DEFORMITY AND KYPHOSIS DORSALIS ADOLESCENTIUM

In spite of the clinical and roentgenographic similarities between the two conditions, only three writers [12, 82] have considered them comparable. They, however, deny that these conditions are similar for a number of reasons which follow; the author's opinion as to the validity of each reason is stated parenthetically.

1. In post-tetanic kyphosis there are hardly ever changes in the intervertebral discs. (Disc changes do occur, however, and in juvenile kyphosis they are also infrequent. Nuclear herniations occur more frequently in juvenile kyphosis because they are normally found more often at the lower level. Nuclear herniations probably play only a secondary rôle.)

2. Post-tetanic kyphosis is found more often than juvenile kyphosis. (This is contradicted by statistics.)

3. There is an overlapping between post-tetanic kyphosis of slight degree and that of severe grade. (This is just as true of juvenile kyphosis.)

4. Juvenile kyphosis is a primary epiphyseal affection. (The vertebral epiphyses are not the primary seat of the affection. It will be pointed out, however, that a developmental defect of a similar nature is a factor in both conditions.)

5. In juvenile kyphosis, the wedge form of the bodies is blunt, not acute. (This blunt wedge appears in only a limited number of cases of juvenile kyphosis and also in post-tetanic kyphosis.)

6. Irregular opacities are seen in the vertebral bodies in juvenile kyphosis. (These are seen also in the other type.)

7. The kyphos of adolescence is situated lower than that following tetanus. (The difference is only one of location, as shown in Figure 7. The muscle action of tetanic convulsions has already been shown to be responsible for the level of the associated deformity. A comparison of Curves *3* and *4* in Figure 7 shows the static origin of juvenile kyphosis. Such a difference bears no relation to the diminution in functional capacity of the spine which underlies both conditions.)

The following similarities cause one to seek a factor common to both conditions:

1. In most cases, there is a kyphos affecting the thoracic spine. The kyphos is of similar degree and extent and is found in that portion of the thoracic spine that is exposed to the type of stress which is peculiar to each condition.

2. The deformity occurs predominantly during adolescence, and for the most part in males.

3. Although a familial occurrence is seen frequently in juvenile kyphosis, there is little in the history, general physical examination, and later symptoms to suggest a defective physical background or disease process in the spine. Following the appearance of the deformity, the symptoms are referable to a mechanical decompensation of the vertebral column.

4. Both entities are associated with an overburdening of the spine, which extends over a longer or shorter period of time, and the deformity appears in a short time following the first exposure to stress.

5. The changes in the vertebral bodies consist of flattening and wedging, irregularity in density, early appearance of fragmentation in the end-plate regions, indentation of the upper and the lower surfaces, notching of the anterior surfaces, and tendency toward recovery of contour. Although such changes do not occur in all cases, they are present in one condition or in the other in such number that they may be said to be common to both.

6. In both types of kyphosis, fixation and permanence of the deformity are frequent findings.

7. Cases have occurred in which changes in the lower thoracic verte-

brae, characteristic of juvenile kyphosis, have been found subsequent to a post-tetanic deformity above this point.

SUMMARY

Cases have been reviewed and described to show that kyphosis of the vertebral column may follow tetanus, with or without demonstrable fracture of the vertebral bodies. The force initiating this deformity is explained on the basis of the contraction of certain muscle groups during tetanic convulsions. Although there is a greater tendency for vertebral fracture to occur in adults, the majority of post-tetanic kyphoses occur in adolescents in an age group corresponding to that of juvenile kyphosis. The similarity to juvenile kyphosis includes also the clinical and roentgenographic characteristics of both conditions, with the exception of the level of the deformity, and this difference is explained by the "dynamic" level of stress in post-tetanic kyphosis in contrast to the "static" level of stress in juvenile kyphosis. Post-tetanic spinal deformity in adults is the result of a particularly severe and prolonged attack of tetanus. Because it does not seem possible to explain the occurrence, age incidence, and roentgenographic changes in adolescents purely on the basis of the intensity of tetanic convulsions, and because of the striking resemblance to juvenile kyphosis, a common factor of weakness in certain adolescent spines is sought to explain this. Further study has indicated that this factor, most prominent in juvenile kyphosis, is an overacceleration of endochondral ossification during the periods of most active body growth, causing ossification in the metaphyses of the vertebral bodies to lag behind a predominating proliferation of columnar cartilage.

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SERUM PHOSPHATASE—ITS CLINICAL APPLICATION IN DISEASES OF BONE *

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Since the discovery of the enzyme phosphatase, there has been increasing interest in the relation of the activity of the enzyme in the serum to various pathological conditions, notably bone disease. Although its clinical applications are as yet limited, sufficient evidence has been produced in the past few years to establish the importance of serum phosphatase in the differential diagnosis and prognosis of several bone diseases. We became interested in this problem several years ago and our investigations were at first limited to the relationship of serum-phosphatase level to the healing of fractures, the results of which have been published.[11] It is our purpose in this paper to review the literature pertaining to the clinical application of serum phosphatase to bone disease and, in addition, to present the results of our own investigations.

Inasmuch as it has been shown that the enzyme phosphatase is an important factor in bone metabolism, we, as a group of orthopaedic surgeons, should be familiar with its function and variations in certain diseases of the bone. We have been accustomed for years to obtain serum-calcium and phosphorus determinations in bone disease and have known that these are affected to a greater or lesser extent in diseases of bone, but to these must be added a third variable, the serum phosphatase, which undergoes still greater changes.

Robison [14] and his coworkers in 1923 demonstrated that the enzyme phosphatase was capable of hydrolyzing phosphoric esters such as glycerophosphates and hexosephosphates into inorganic phosphates. They discovered the presence of the enzyme in the kidney, the intestinal mucosa, muscle, and plasma, as well as in bone. Growing bone, especially, they found contained a high concentration of the enzyme and they concluded that a relationship existed between the enzyme and bone metabolism.

Kay [9] summarized the evidence in favor of this view as follows: "The enzyme in bone was not confined, however, to the epiphysis but was present in considerable, though lesser, quantities in the shafts of long bones as well. The surprising and striking fact that such a relatively inert tissue as bone should contain this active enzyme, so conveniently situated for the deposition of calcium phosphate, pointed directly to the probability that the enzyme played some specific part in bone formation.

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Up to the date of the discovery of this enzyme in bone, the cause of the deposition of calcium phosphate in this tissue and its non-deposition elsewhere had not been satisfactorily explained. The hydrolysis of some phosphoric ester, the calcium salt of which is readily soluble in water or plasma, by an enzyme present to a greater extent in ossifying cartilage than in any other tissue, leading to the *local* production in the calcifying zone of an inorganic phosphate-ion concentration considerably higher than that in the blood, offered an explanation of calcification which seemed to fit the facts much more closely than the theory of specific adsorption by ossifying cartilage . . . which was one of the less unsatisfactory hypotheses. . . ."

Kay [6, 7, 9], Bodansky and Jaffe [1], and others [13, 16] demonstrated that there was an increase of serum phosphatase in several diseases of the bone. It is known that there are variations of serum-phosphatase activity with other conditions—notably jaundice, nephritis, and accompanying a high carbohydrate diet—and these facts must be borne in mind in interpreting the serum-phosphatase readings. However, up to the present, determinations of serum-phosphatase activity still find their most useful application in the diagnosis of diseases of bone.

It has also been shown that variations in serum-phosphatase activity occur at different age levels, the readings for children being highest with a gradual decrease with advancing age. According to Bodansky and Jaffe, the normal value of serum phosphatase for adults is 2.6 units per 100 cubic centimeters, with a range between 1.5 and 4 units; and for children, 7.2 units per 100 cubic centimeters, with a range between 5.2 and 13 units. The Bodansky method of determination has been used throughout in this study.

The significance of variations in serum-phosphatase activity in the various bone diseases studied is not yet clearly understood. Several theories have been advanced, none of which is entirely tenable. Robison's [15] theory was that the level of the enzyme was an index of the "cellular activities leading to the formation of bone". Kay [8] explained the high plasma phosphatase in disease of bone by "leakage at more than the normal rate, possibly because it is produced in excessive amount in attempted compensation for the lesion". Woodard, Twombly, and Coley [17] concluded that serum-phosphatase activity was "a measure of the amount of new bone formation taking place in the body or of an attempt on the part of the body to form new bone". Bodansky and Jaffe conceded that the higher serum phosphatase of the young was likely due to the greater "cellular activities leading to this formation of bone", but argued that this explanation did not account for the increase of serum phosphatase to the extremely high levels found in rickets or in Paget's disease. They contended that it represents the capacity of bone for cellular activities and that, due to certain stimulations, this capacity is increased with formation of abnormal bone or osteoid tissue, as in the case of Paget's disease and rickets. They found from their studies that

destruction of bone *per se*, unless accompanied by new bone or osteoid formation, was probably not associated with a marked rise of serum phosphatase.

To ascertain the diagnostic and prognostic value of phosphatase determination, an analysis has been made of the readings taken on several hundred cases showing bone lesions, the results of which follow.

FIG. 1

PAGET'S DISEASE

In Paget's disease with multiple bone involvement it has been shown that the serum-phosphatase activity may rise to twenty or more times the normal figures, while the calcium and phosphorus content remains normal. Bodansky and Jaffe reported levels of from 15 to 125 units for the polyostotic type and of from 5 to 23 for cases with localized lesions. Gill and Stein [4] have suggested the use of serial phosphatase determinations as an index of the progress of the condition. They found that with a diet low in calcium, low in phosphorus, and high in magnesium there was a tendency toward disappearance of the symptoms and a gradual decrease in the serum-phosphatase activity. Bodansky and Jaffe noted in

FIG. 2

their study of Paget's disease that the oldest patients showed the lowest values for serum phosphatase, which they believed to be due in part to spontaneous healing by sclerosis.

The levels of serum phosphatase in our series of Paget's disease (Table I), while relatively lower than those of Bodansky and Jaffe, corresponded in that the higher values were found in the polyostotic type and there was a tendency for the level to be lowered with healing by sclerosis.

An unusually high level of serum phosphatase accompanying an obscure bone lesion is evidence suggestive of Paget's disease. Yaguda [18] reported a case which was originally diagnosed as metastatic carcinoma, but which showed an increased phosphatase. Later developments showed the localized bone condition to be Paget's disease. One case of our series (Case 2, Table I) is illustrative of the diagnostic value of serum phosphatase. This woman was seen because of back symptoms, and roentgenograms revealed a destructive lesion involving several of the vertebral bodies. (See Figure 1.) Routine calcium, phosphorus, and phosphatase determinations were obtained and the phosphatase reading was found to be 11.3 units. Paget's disease was then suspected and confirmed by roentgenograms of the pelvis and the long bones. (See Figure 2.)

HYPERPARATHYROIDISM

This condition is characterized by a high-calcium, low-phosphorus, and high-phosphatase content of the serum. As is well known, the blood chemistry returns to normal shortly after removal of the parathyroid adenoma. The average serum-phosphatase level is lower than that seen in Paget's disease, the average for our series being 8.3 units. (See Table II.)

TABLE I

Osteitis Deformans

Case	Sex	Age (Years)	Calcium	Phosphatase	Bones Involved
1. E. P.	Male	56	10.2	20.40	Pelvis, femur.
2. N. M.	Female	63	10.0	11.30	Pelvis, femur, spine
3. J. D.	Male	55	10.0	6.24	Pelvis, spine
4. G. E.	Male	63	9.8	35.05	Both tibiae
5. B. K.	Female	52	9.7	31.50	Pelvis, tibia
6. E. J.	Male	41	9.4	6.62	Humerus (fracture)
7. M. R.	Female	59	10.2	7.30	Tibia
8. W. S.	Male	63	9.8	2.62	Tibia (fracture)
9. D. W.	Male	45	9.0	37.00	Humerus (fracture)
10. J. LeB.	Male	55	10.2	19.10	Humerus (fracture)
11. A. S.	Female	73		11.90	Lumbar spine
12. F. B.	Male	56	9.3	6.92	Pelvis

On one of these cases (Case 3, Table II) daily blood-chemistry determinations were obtained before and for several weeks following operative removal of the adenoma. (See Figure 3.) As was to be expected, the serum calcium rapidly returned to normal following operation. The phosphorus showed only a slight rise, but was not characteristically low prior to operation. We are unable to account for the unusual increase in phosphatase activity occurring after operation and reaching a peak of 18.8 units two weeks later. This would seem to suggest an increased cellular activity following removal of the adenoma, but was probably due to increased carbohydrate metabolism, as the patient received almost daily intravenous injections of glucose.

TABLE II

Osteitis Fibrosa Cystica

Case	Sex	Age (*Years*)	Calcium	Phosphatase	Bones Involved
1. E. D.	Female	51	12.60	10.72	Femur, forearm
2. J. P.	Male	49	10.20	6.82	Mandible
3. J. H.	Male	51	18.40	7.36	Spine, femora

FRACTURES

In a previous publication [11], one of us (C. L. M.) analyzed serial serum-phosphatase determinations in a large series of fractures. For the present discussion on fractures, we are taking the liberty of quoting freely from this article.

"Regen and Wilkins [12], Botterell and King [2] in experimental work on animals have shown that the phosphatase activity of bone at the site of fracture was greatly increased as compared with that of bone from other sites in the same animal. They found that the increase may be as much as ten to twenty times normal and reached its maximum about three weeks following fracture." That there is an increase in the serum phosphatase following fractures has been demonstrated by several investigators [1, 5, 8, 10].

The purpose of our investigation was to determine:

1. If there was a consistent rise in serum-phosphatase activity following fractures.

2. If the rise was not consistent, was there any correlation between the level of serum phosphatase and (*a*) the location of the fracture, and (*b*) the extent of the injury.

3. If the serum-enzyme level could be used as an index of the rate of healing of the fracture and as a prognostic sign in the development of delayed or non-union.

Serial determinations were made the day following fracture and at weekly intervals for the next three weeks. It was found that in the majority of fractures there was an increase in serum-phosphatase activity, but that this was not consistent. The average phosphatase levels for the seventy-five cases studied were as follows: on admission, 3.74 units; seventh day, 4.43 units; fourteenth day, 4.69 units; twenty-first day, 4.77 units.

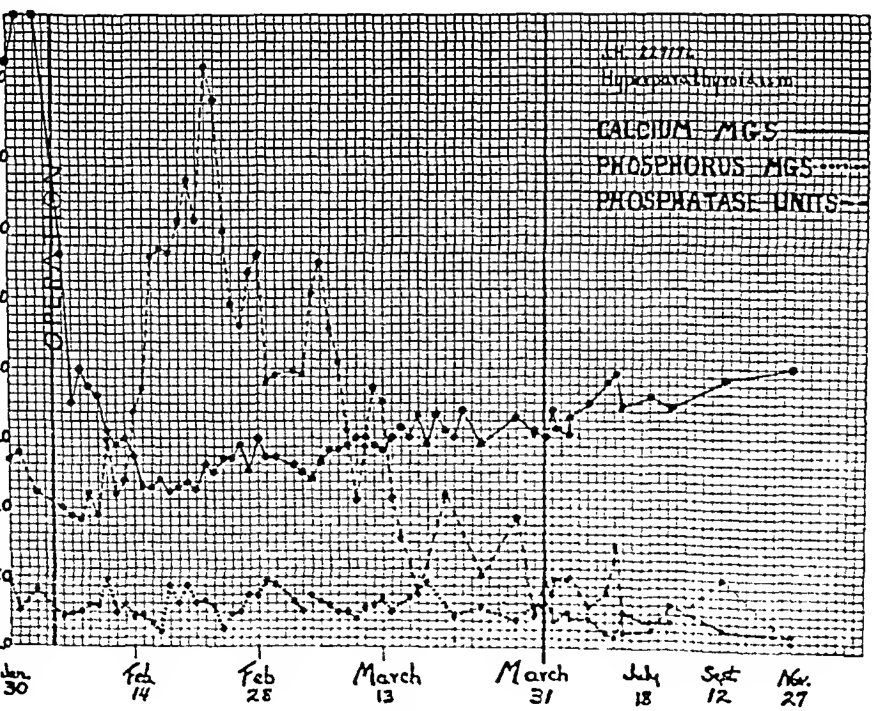

FIG. 3

TABLE III

Bone Tumors (Primary and Metastatic)

Case	Sex	Age (Years)	Calcium	Phosphatase	Tumor	Bone Lesion	Bones Involved
1. J. M.	Male	39	9.2	2.61	Osteogenic sarcoma	Lytic	Femur
2. N. M.	Male	48	10.2	7.01	?	Lytic	Spine
3. M. W.	Female	59		4.26	Carcinoma of bladder	Lytic	Tibia
4. F. C.	Male	62		2.37	?	Lytic	Spine
5. M. S.	Female	40	10.6	2.32	Giant-cell tumor	Lytic	Femur
6. A. T.	Male	41	10.2	3.51	Giant-cell tumor	Lytic	Femur
7. K. S.	Female	57	9.2	2.21	Lymphosarcoma	Lytic	Spine
8. S. L.	Female	52	8.4	4.49	Carcinoma of breast	Lytic	Femur
9. M. D.	Male	14	10.2	3.12	Sarcoma	Lytic	Ilium
10. W. F.	Male	82	8.2	9.56	Carcinoma of prostate	Osteoblastic	Ilium

There was found to be no correlation between the extent of the injury or the location of the fracture and the level of the phosphatase activity. Lastly, it was found that the serum-enzyme level could not be used as an index of the ability of the fracture to heal, as many cases of delayed and non-union showed relatively high readings.

BONE TUMORS

That there is an elevation of serum phosphatase accompanying certain tumors of bone has been demonstrated by various observers. Franseen and McLean [3] analyzed a series of bone tumors and found that there was significant elevation of the serum-enzyme activity in the osteoblastic

TABLE IV

Tuberculosis of Bone (Children)

Case	Sex	Age (Years)	Calcium	Phosphatase	Site of Lesion	Duration	Status
1. E. W.	Female	6½	10.4	6.00	Spine	2½ years	Active
2. S. B.	Female	15	9.8	4.35	Hip	10 years	Active
3. B. C.	Male	4	9.8	4.21	Spine	8 months	Active
4. D. W.	Male	1½	10.4	3.59	Spine	4 months	Active
5. J. P.	Male	10	10.8	4.64	Spine	8 months	Healing
6. G. L.	Male	3½	9.7	3.69	Spine	1 year	Active
7. E. T.	Male	1	9.6	2.58	Ulna, tarsus	6 months	Active
8. W. B.	Male	9	9.4	4.22	Spine	6½ years	Active

TABLE V

Tuberculosis of Bone (Adults)

Case	Sex	Age (*Years*)	Calcium	Phosphatase	Site of Lesion	Duration	Status
1. M. D.	Female	33	10.0	4.42	Spine	1½ years	Active
2. K. M.	Male	30	10.0	1.90	Spine	9 years	Active
3. R. J.	Female	18	9.8	2.16	Spine	5 years	Active
4. J. S.	Female	22	10.0	2.12	Spine	12 years	Healing
5. E. G.	Female	35	10.2	3.02	Spine	6 months	Healing
6. H. D.	Male	16	10.0	3.79	Spine	5 years	Healing
7. I. P.	Male	30	10.2	2.33	Spine	4 years	Active
8. H. B.	Male	15	10.0	4.35	Spine	2 months	Active
9. J. T.	Male	51	9.4	3.22	Hip	2 years	Active
10. K. M.	Female	35	9.6	2.16	Spine	2½ years	Healing
11. E. C.	Male	40	9.0	3.46	Spine	5 years	Active
12. R. A.	Male	27	10.1	2.14	Spine	3 months	Active

type of osteogenic sarcoma. They demonstrated that, with surgical removal of the tumor mass in this type of osteogenic sarcoma, there was a rapid fall of serum phosphatase to normal, to become elevated again with recurrence of the tumor. They reported no increase in the serum-enzyme activity in cases of multiple myeloma and elevation in cases of metastatic carcinoma of bone, and suggested that the serum-phosphatase level might be of use in the differential diagnosis of these conditions. Woodard, Twombly, and Coley concluded that the bone-forming characteristics of a tumor are of more importance than its malignancy in determining whether its presence will give rise to an elevated serum phosphatase. They found a high level of serum-phosphatase activity in the osteoblastic type of osteogenic sarcoma and in the osteoblastic type of metastatic carcinoma and little or no elevation in the osteolytic types. They suggested the use of serum-phosphatase determinations in differentiating between osteoblastic osteogenic sarcoma and chondrosarcoma, and between osteoma and

TABLE VI

Osteomyelitis

Case	Sex	Age (*Years*)	Calcium	Phosphatase	Bones Involved
1. P. L.	Male	17	9.8	2.04	Femur
2. J. C.	Male	31	9.6	2.78	Femur
3. C. H.	Male	30	9.8	2.11	Femur
4. W. C.	Male	20	9.6	1.30	Femur
5. J. McN.	Male	28	10.4	4.02	Femur
6. A. T.	Male	15	9.6	2.37	Humerus
7. M. S.	Female	15	10.2	3.66	Tibia

an old myositis ossificans, tumors which may show almost indistinguishable roentgenographic pictures.

Table III gives figures for various types of bone tumors investigated in our Clinic. It would appear that in general there is little or no elevation of phosphatase activity accompanying osteolytic lesions. Unfortunately, no biopsy was obtained and no primary lesion discovered in Case 2 (N. M.), showing a slight elevation of serum phosphatase.

BONE AND JOINT TUBERCULOSIS

As would be expected with a purely destructive lesion of bone, no elevation of serum-phosphatase activity was found in children or in adults with bone and joint tuberculosis. (See Tables IV and V.) The average level of serum phosphatase in the children studied was somewhat below normal, which might be explained on the basis of poor nutrition. There seemed to be no correlation between the activity or stage of the lesion and the phosphatase level. It was not felt, therefore, that the serum-phosphatase determinations in this condition were of prognostic value.

OSTEOMYELITIS

Several observers have reported a slight rise in the serum-phosphatase activity accompanying osteomyelitis. One might expect a slight rise during the regenerative process with the formation of new bone, and Bodansky and Jaffe suggested this as an explanation for the elevation when present. However, we found the levels in our series to be within normal limits, whether in the acute or in the regenerative stage. (See Table VI.)

RICKETS

Bodansky and Jaffe reported a series of twenty-seven cases of active rickets with serum-phosphatase levels ranging from 30 to 190 units, depending upon the severity of the condition. They found that with adequate treatment there was a marked decrease of serum phosphatase associated with other evidence of rapid healing. They concluded that a normal serum-phosphatase level was evidence of a healed process.

SUMMARY

1. In reviewing the relation of serum-phosphatase activity to the more common diseases of bone, it has been found, in general, that there is an increase in serum-phosphatase activity accompanying the formation of unusual amounts of new or of abnormal bone. There appears to be little or no increase associated with the purely destructive lesion of bone.

2. Determinations of serum phosphatase are an important aid in the diagnosis and differential diagnosis of Paget's disease, osteitis fibrosa cystica, and tumors of bone.

3. The level of serum-phosphatase activity cannot be used as an index of healing or of the ability of a fracture to heal.

4. No significant changes in serum-phosphatase activity were noted in cases of bone and joint tuberculosis and of osteomyelitis.

5. Serial phosphatase determinations are suggested as a criterion of effective therapy in Paget's disease, hyperparathyroidism, osteoblastic osteogenic sarcoma, and rickets.

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RUPTURE OF THE SUPRASPINATUS TENDON *

BY LEO MAYER, M.D., NEW YORK, N. Y.

In his book on the shoulder, Codman reports that, despite his many years of study, he has never had an *opportunity of operating on an early case* of ruptured supraspinatus tendon. His knowledge of the pathology was, therefore, *gained entirely from observations of late cases*. These facts were emphasized by Codman in a lecture delivered before the New York Academy of Medicine in the spring of 1935. By a peculiar coincidence, on the day after the lecture I had occasion to diagnose a tear of *the supraspinatus tendon which had occurred less than forty-eight hours* before, and, during the next three months, three similar cases came under my observation.

Small though the series is, the study of these cases has taught me so much, and my errors have cost me so dearly, that it seems worth while to present these experiences, if for no other reason than to prevent others from making the same mistakes.

Of the symptomatology, nothing needs to be said. It is all described so clearly in Codman's book that repetition is unnecessary. The observed pathological changes are, however, important. Common to all four cases was a complete tear of the supraspinatus tendon. This occurred at the bony insertion,—only a few minute shreds of tendon were found adherent to the greater tuberosity. The proximal end of the tendon had retracted upward and inward about one and one-half inches. It was hard to distinguish the tendon from the torn capsule of the shoulder joint, which, like the supraspinatus tendon, was found ruptured in all four cases. The torn capsule formed a circular rent approximately one and one-half inches in diameter. The upper border of this rent was remarkably smooth, evidently due to the fact that the smooth surface of the bursa had wrapped itself over the edge of the tear. Through this rent the cartilage of the head was visible. In the first case the bursa was filled with blood clot; in the other three no evidence of bleeding was found. In two cases the infraspinatus tendon was *torn* away with the supraspinatus. In one case the long head of the biceps was completely torn just as it entered the joint, and in another this tendon was frayed and partly torn.

OPERATIVE TECHNIQUE

In the first three cases I made a straight incision downward from the acromion directly in line with the torn supraspinatus. This gave adequate exposure only after splitting the deltoid for more than three inches. At the time of the operation this caused me no misgivings, but in the aftercare of these patients I noted a marked weakness of the anterior fibers of

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the deltoid. This must, I believe, have been caused by division of minute branches of the circumflex nerve passing forward in the substance of the muscle. Certain it is that it took months of postoperative treatment before the muscle recovered, and in Case 2 it never regained its full strength. For this reason, in the fourth case I avoided splitting the deltoid by running the incision further anterior between the pectoralis major and the deltoid. To gain adequate exposure, about one inch of the clavicular portion of the deltoid was stripped away from the clavicle subperiosteally. By rotating the arm internally, the greater tuberosity was brought into the wound and, by adequate retraction, the proximal stump of the torn supraspinatus could be reached.

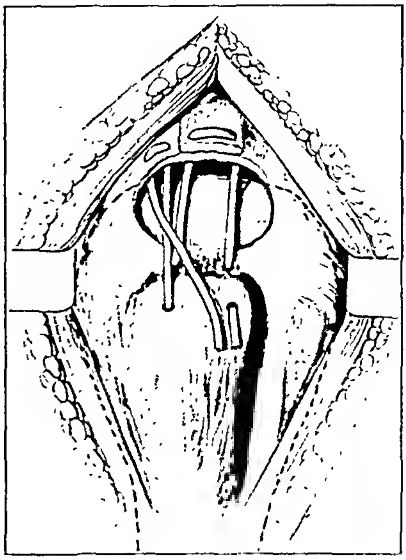

FIG. 1

This illustrates the manner of passing the fascial strand through the torn supraspinatus tendon and capsule above and the greater tuberosity of the humerus below.

The repair of the torn capsule of the supraspinatus tendon was accomplished in the first three cases by passing three silk mattress sutures through drill holes in the greater tuberosity and the upper margin of the capsule. Attempts to tie these sutures and to approximate the edges of the capsules were futile until the arm was abducted 120 degrees. In other words, despite the short period of time between the injury and the operation, so much retraction had occurred that the tension of a strong suture was insufficient to overcome the shortening. Conversely, after the sutures had been tied, the attempt to lower the arm to the side of the body caused the sutures to tear out. It was, therefore, necessary to immobilize the arm in abduction of 120 degrees.

For this reason, the after-treatment presented a serious dilemma. If immobilization in the abducted position were continued unduly long, an abduction contracture would ensue; if, however, the arm were brought down too soon, the sutures would not hold and the supraspinatus, together with the capsule, would again be torn away from the greater tuberosity. By analogy with the healing of tendons after transplantation on the foot, I figured that in two weeks a fair degree of union would be present and, therefore, in the first three cases I instituted gentle active and passive motions of the arm at the end of that period. Plaster splints which held the arm abducted about 60 degrees were used between the exercise periods. Despite the cooperation of the patients and the assiduity of my physiotherapists, the results were disappointing. In Case 1, after six months of treatment, active abduction was possible only to 90 degrees; in Case 2, to

120 degrees; in Case 3, to about 130 degrees. Passively there was little or no restriction and the patients did not complain of pain, but the shoulders were far from normal.

In treating my fourth patient, who fortunately did not come to me until I was aware of my mistakes, I made a number of important changes in the technique. The first was the use of the anterior incision running between the pectoralis major and the deltoid, instead of the straight incision, splitting the deltoid fibers. Next, I decided not to rely upon silk, but to use a strong fascial suture for the repair of the torn capsule and tendon. Threaded on a Gallie needle, these fascial strands, three-quarters of an inch wide, were passed through drill holes in the tuberosity and the upper margin of the capsule (Fig. 1). With the arm abducted 120 degrees, they were drawn through and fastened by a No. 3 chromic-gut stitch. Finally, instead of mobilizing the arm at the end of two weeks, I waited four weeks. An anxious two weeks followed, for it was at first impossible for the patient to lower the arm to less than 90 degrees. Gradually, however, by means of continuous gentle traction downward, the abduction contracture gave way. Of course, active exercises for the abductors were kept up rigorously. The final result was a perfect range of motion, despite the fact that this fourth case was complicated by a tear of the infraspinatus.

The lessons to be learned from my brief series are the following:

1. Complete tear of the supraspinatus tendon can be diagnosed and requires operative treatment.

2. It is frequently complicated by injuries to other tendons, either the infraspinatus or the biceps.

3. The incision should avoid injury to the deltoid. My own experience favored an anterior incision running between the pectoralis major and the deltoid, with a slight stripping of the clavicular portion of the deltoid.

4. Fascia, not silk, should be used for the repair, and this should be passed through drill holes in the greater tuberosity.

5. The shoulder should be immobilized in 120 degrees of abduction for four weeks. An abduction contracture will probably ensue, but this will yield to treatment within several weeks.

6. The period of postoperative treatment is likely to last three or four months before normal range of motion and good return of strength can be expected.

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RUPTURE OF THE SUPRASPINATUS—1834 TO 1934

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Orthopaedic surgeons are beginning to take an active interest in lesions of the shoulder, and particulàrly in the one mentioned in the above title. This is indicated by the attendance at a symposium on the shoulder, held by the American Academy of Orthopaedic Surgeons in January 1937, at Cleveland, Ohio. Moreover, since the January number of this essentially orthopaedic Journal contained a fourteen-page article on "Rupture of the Supraspinatus", one senses editorial recognition of the assumption of responsibility for undertaking to keep its readers informed of progress in this field. This is another indication of interest in the last joint to be relinquished by general surgery to orthopaedic surgery, and is tantamount to an opinion that in hospitals the orthopaedic departments, rather than the general surgical departments, should be held responsible for the treatment of shoulder injuries,—a field in which little interest has been displayed by anyone. The immense cost to industry of neglected shoulder injuries (now considered more important than the patient's pain) demands that someone should assume the duty of caring for these cases and studying out methods of treating them effectively.

It matters little that the author of the article in the January issue, H. Alan Skinner, is a professor of anatomy and not an orthopaedic specialist. No doubt his interest in the subject was aroused by some of his clinical colleagues whose good-natured misstatements led him to begin his paper with the following sentences: "Separation of the supraspinatus from its attachment to the humerus is a condition which has been recorded by various writers, notably by Codman of Boston, who was one of the first to recognize the prevalence and importance of the condition. There has been a general tendency to accept it clinically as the direct result of trauma without inquiring into the possibility of other etiological factors. Observations upon cadavera, in this Department and elsewhere, suggest a more wide-spread disturbance than mere rupture of a muscle." A few years ago I would have modestly admitted that the first sentence in this quotation was correct, but my eyes have now been opened by a paper, written over 100 years ago, which seems to me so good that I have requested the Editor of this Journal to reprint it in full. This paper shows that an English anatomist, J. S. Smith, had, in 1834, made the essential observations which were the foundation of my 500-page book, "The Shoulder", published in 1934. Nearly the whole of Skinner's article (which, I submit, is nevertheless a very good one) was also covered by this century-old communication, although the word "supraspinatus" was not mentioned in its title. This paper by Smith had eluded me, as well as the literary bureau of the American College of Surgeons, whom I had employed to search for references to the supraspinatus. It appeared first in the English

Medical Gazette in 1834 and was reprinted in the *American Journal of Medical Sciences* in the following year. I am indebted to K. O. Haldeman and Ralph Soto-Hall, of San Francisco, for calling my attention to it in their excellent article, "Injuries to Muscles and Tendons".

These authors may be credited with disinterring this early paper, although I may at least claim a part in having previously resurrected its subject and in showing the importance of such injuries in modern industry. It was my interest in such lesions which induced Akerson to look for this lesion in a series of cadavera, and perhaps influenced Keyes to do so likewise. However, Meyer's work was quite independent, as was part of Fowler's. At any rate, Akerson at Harvard, Keyes at Washington University, Meyer at Stanford University, Fowler at St. Francis Hospital, Evanston, Skinner at the University of Western Ontario, and, no doubt, others have now confirmed Smith's century-old findings, although the conclusions each has drawn have differed in some degree. The findings in all these studies are essentially the same,—*i.e.*, varying percentages of defects in the capsule of the shoulder joint at or about the region of the insertion of the supraspinatus tendon. Frequently the long biceps is also involved, having become detached from the glenoid rim and having formed a new attachment in the bicipital groove. When a defect is large, it forms a communication between the true joint and the subacromial bursa. All investigators agree on the description of these lesions and on the fact that they occur so frequently that anyone who will search for them in elderly subjects will not have to examine many before he will find one, and it is quite likely that he will find a similar one in the other shoulder of the same subject. As a rule, these defects have a thin falciform edge, adapted to the cartilage beneath, reminding one of the edges of the semilunar cartilages of the knee joint. This falciform edge is interpreted by Meyer to be part of the original tissue left after the wearing away of the tendons by repeated friction in elevation of the arm as the tuberosity rubs against the acromion. My own opinion is that these edges are newly formed tissue with which nature has attempted, vainly, to fill defects caused by rupture and retraction of the tendons. This opinion is founded on observation at operation at periods varying from a few weeks to a few years after the history of a severe shoulder injury, and by successful results after suture of these defects.

I shall not go into further detail, for my arguments are fully set forth in my book. My present purpose is to show that similar observations, which were made in a dissecting room over 100 years ago, were accurately described and were, I believe, more correctly interpreted than such findings have been by our modern anatomists, Meyer and Skinner.

I feel that it is of great importance that the question of whether these falciform edges are remnants left after attrition or are the results of efforts at repair of ruptures should be definitely decided. If, as I believe, they are traumatic, much pain and disability, as well as great economic loss, may be avoided by their prompt recognition and repair.

The following paper by Mr. J. S. Smith, published in the *American Journal of Medical Sciences* for May 1835 (Volume XVI, page 219) is reprinted in full.

PATHOLOGICAL APPEARANCES OF SEVEN CASES OF INJURY OF THE SHOULDER-JOINTS WITH REMARKS

The *Medical Gazette* for May 24th last, contains the following interesting contribution, from John G. Smith, Esq., to our knowledge of the pathology of the shoulder-joint. Mr. S. is unable to give any previous history of the different cases; the whole of them occurred in bodies brought to his theatre for dissection.

"CASE I. In the body of a man brought to the dissecting-room, under the old system of violation of the grave, in the month of February, 1832, the following pathological condition of the left shoulder-joint was observed:—

"On making a transverse section in the centre of the deltoid muscle, for the purpose of reflecting it, the bursa situated beneath was observed to be much larger than usual, very much thickened, and communicating with the general cavity of the shoulder-joint by a large irregular opening. On further examination, it was noticed that the tendinous insertion of the subscapularis muscle had been entirely torn away from the lesser tubercle; the supra-spinatus, infra-spinatus, and the teres minor muscles, had likewise been completely detached from the greater tubercle. The tendon of the long head of the biceps had been torn away from the upper part of the glenoid cavity, and entirely withdrawn from the joint: it was found to be firmly attached to the anterior margin of the bicipital groove. The head of the humerus moved freely in all directions on the glenoid surface of the scapula, and the size of the cavity of the joint was much increased, from the extensive laceration of the capsular ligament; it included the whole of the neck of the bone and both tubercles. The appearance of thickening of the capsule below would seem to indicate that it had likewise suffered laceration in this situation at the time of the injury. A small portion of the outer margin of the glenoid cavity had been fractured off, and, with the under surface of the acromion process, and the tubercles of the humerus, were partially covered with portions of enamel-like or porcelain secretion; and numerous bands of organized fibro-ligamentous substance extended across the cavity of the joint in different directions. There was a fracture of the humeral extremity of the clavicle, which extended into its articulation with the acromion.

"CASE II. Mary B. . . . , aet. 30, died of consumption in St. George's Workhouse, and was removed to the theatre for dissection, in November, 1832, under the new regulations provided by the Anatomical Bill.

"The left shoulder-joint presented the following appearances:—The bursa beneath the deltoid muscle communicated, by a large irregular opening, with the general cavity of the joint: the tendon of the subscapularis muscle was partially torn from the lesser tubercle of the humerus, but the insertions of the supra and infra-spinatus muscles and the teres minor, remained perfect. The round tendon of the long head of the biceps muscle was ruptured, leaving a portion, about half an inch in length, attached to the upper part of the glenoid surface: the lower portion of the tendon had been drawn from the cavity of the joint, and lay firmly attached to the margin of the bicipital groove. The ruptured extremities of the tendon were perfectly smooth and rounded, and the superior portion had become much flattened: small bands of fibro-ligamentous structure were observed, but none of that peculiar enamel-like secretion noticed particularly in the preceding case.

"CASE III. Ann D. . . . , aet. 38, died January 1st, 1833: removed from St. George's Work-house, for the purpose of dissection, under the new regulations.

"The following account of the appearances of the right shoulder-joint is extracted from the notes entered at the time, in the dissecting-room journal, by Mr. G. Knox who dissected the extremity. On removing the deltoid muscle, the head of the humerus came into view, presenting a larger surface of bone than usual: on further examination,

it was found that the tendon of the subscapularis muscle had been partially torn away from the lesser tubercle, and the original insertions of the supra-spinatus, infra-spinatus, and teres minor muscles, had been completely separated from the greater tubercle. The tendon of the long head of the biceps had also been torn from its origin, and had become attached to the upper part of the bicipital groove.

"The under surface of the acromion process was found hardened by the friction of the head of the humerus, and covered by a peculiar enamel-like secretion. The capsular ligament appeared unusually thick at the lower part, which gave rise to the idea it had been lacerated at the time of the injury, and had become reunited by the effusion of coagulable lymph.

"CASES IV AND V. Catherine S. . . . , aet. 56, died February, 1833; was removed from St. George's Work-house, under the new regulations, with a medical certificate signed 'sudden death'. She was a short, stout, muscular subject, and, upon inquiry, proved to have been a hard-working woman at the wash-tub up to the time of her death. The shoulder-joints presented the following appearances:

"*In the right shoulder:* The bursa beneath the deltoid muscle communicated with the general cavity of the joint, by a jagged irregular opening about the size of a half-crown. The tendon of the subscapularis muscle was torn from the lesser tubercle, and the tendon of the supra-spinatus muscle detached from the greater tubercle; both having become united with the common capsule. The tendon of the long head of the biceps had been torn from the upper part of the glenoid cavity, withdrawn from the joint, and found to be firmly attached by ligamentous structure to the margin of the bicipital groove. There were a number of small exostoses on the tubercles, covered with the enamel-like secretion, which corresponds to a similar appearance on the under surface of the acromion process.

"There was an oblique fracture of the acromion process of the scapula, which had separated about an inch of its expanded extremity; it had not united by bone, but had formed an artificial joint through the medium of cartilage, and was further strengthened by a fibro-ligamentous capsule.

"The appearance of the biceps muscle was very remarkable, and first directed the attention to the condition of the joint; the portion of the belly of the muscle appertaining to the long head, was remarkably short, and the short head, unusually developed, appeared in great measure to supply the place of the other.

"*In the left shoulder:*—On dividing the deltoid muscle, the bursa at its under surface was found very much thickened and enlarged, and an opening observed which communicated with the articulation. On further examination, this opening was found to be caused by a partial separation and detachment of the supra-spinatus and subscapularis muscles, from the larger and lesser tubercles; the surfaces from whence they had been torn being within the capsular ligament. The inner surface of the capsule presented a very rough fibrous appearance, occasioned by the portions of the lacerated tendons; the synovial membrane presenting small villous productions, the result, apparently, of organized lymph.

"The tendon of the biceps was wanting in the joint, having been torn through and divided into a number of fibres, which were attached to the upper part of the bicipital groove; small bony exostoses had been thrown out on the tubercles, and the cartilaginous surfaces of the humerus and scapula were here and there covered by small patches of the enamel-like secretion.

"The acromion process of the scapula had been fractured precisely in the same situation as that of the opposite side, and formed a similar artificial joint.

"CASES VI AND VII. Thomas K. . . . , aet. 40, died April, 1834; removed from the Islington Infirmary, with a medical certificate signed 'Consumption'.

"*In the right shoulder:*—The bursa beneath the deltoid muscle communicated by an irregular opening with the general cavity of the joint. The tendon of the subscapularis muscle was entirely detached from the lesser tubercle, and the fibres of the muscle itself were drawn downwards from the venter of the bone, presenting a small cavity

beneath, lined by an irregular fibro-ligamentous structure, and communicating with the articulation. The tendon of the supra-spinatus muscle was torn from the greater tubercle, the infra-spinatus and teres minor muscles remained attached; but the muscles appear, at some former time, to have suffered severe tension.

"The tendon of the long head of the biceps muscle was not separated from its origin, but displaced from the groove, and lay loose in the inner part of the cavity of the joint; it is expanded, and bears evidence of having been subjected to pressure and friction; one surface, which corresponds to the head of the bone, is smooth and polished, the other presents a bundle of silvery cords, which may be spread out upon the finger three quarters of an inch in width; the bicipital groove is nearly filled with a fibro-ligamentous substance, similar in structure to numerous small bands, which extend across the joint in different directions, from one point of the synovial membrane to another.

"The capsular ligament had been much stretched, and will readily allow the head of the humerus to be displaced under the coracoid process of the scapula, resting upon the inner margin of the glenoid cavity. There is no distinct evidence of the capsule having been ruptured in any other situation than that already mentioned, communicating above with the bursa beneath the deltoid muscle. There were small bony deposits about the tubercles of the humerus, which were within the general capsule, and here and there small patches of that peculiar porcelain secretion.

"*In the left shoulder:*—The bursa beneath the deltoid muscle was found very large, and its parietes thickened, but it did not communicate with the general cavity of the joint, being separated by a thick layer of lymph. The capsular ligament was perfect, but very capacious, and apparently thicker than natural. The head of the humerus moves very freely in its socket, and may be easily drawn beneath the inferior margin of the glenoid cavity. The tendon of the subscapularis muscle is torn from the lesser tubercle, and the fibres are drawn from a considerable part of the venter of the bone. The tendons of the supra-spinatus, infra-spinatus and the teres minor muscles, remain attached to the greater tubercle, but their fibres have evidently been, at some former time, very much stretched.

"The tendon of the long head of the biceps, as in the preceding case, was permanently displaced from the bicipital groove, and lay at the inner and lower part of the joint, playing over a smooth part of the lesser tubercle; one surface is perfectly smooth and glistening, the other is a flattened band of silvery fibres. There are a number of fibro-ligamentous bands of organized lymph stretching across from one point of the capsule to another. The bicipital groove is nearly obliterated by the same structure, and portions of ossific matter have been deposited.

"*Remarks:*—There are several points of extreme interest in the foregoing cases, connected with the pathological condition of the shoulder-joint consequent upon severe injuries, which present themselves for consideration; and I conceive might be attended with a very useful lesson, if we are careful to avoid all hasty opinions, and only select such practical inferences which may be essential in accounting for many circumstances attending accidents of the shoulder-joint.

"It may assist us in forming a right judgment of the case, point out the most rational method of treatment, and enable us to prevent many bad consequences which frequently follow injuries of this important articulation.

"The first point which suggests itself is, that a severe blow, strain, or dislocation, is more frequently accompanied with severe local injury of the muscles and tendons, in the immediate neighbourhood of a joint, than we should be otherwise inclined to suppose.

"I have formed this opinion from the circumstance, that the seven cases of severe injuries of the shoulder, described above, occurred in the comparative small number of dissections, not exceeding forty individuals: and I think I may therefore safely infer, that these effects consequent upon severe accidents more frequently happen than are suspected, and from inadvertency or other causes are entirely overlooked in the ordinary dissection of bodies.

"It is a curious fact, that in two instances both joints of the same individual should

have presented nearly similar appearances, and that the *same cause* should *probably* have produced exactly similar results.

"The frequency, in these cases, of the rupture, or tearing away *from its origin*, of the tendon of the long head of the biceps muscle, and its subsequent withdrawal from the joint into the bicipital groove, and its complete and permanent displacement in two instances, are facts in themselves of great practical importance.

"The separation of the tendon of the subscapularis muscle from the lesser tubercle, (excepting in one case,) where it was only partially torn away, may be looked upon as the common result of the accident which produced these appearances; not so, however, with the tendons of the supra and infra-spinatus, and the teres minor muscles, from the greater tubercle, which appear to be more uncertain. In two instances all three tendons were torn away; in three cases only the tendon of the supra-spinatus; and in the remaining two cases, the whole of the tendons preserved their natural attachments.

"The capsular ligament appears in all cases to have been extensively lacerated at the upper part, and to have communicated with the bursa beneath the deltoid muscle, with only one exception, which hardly deserves to be excluded, from the very evident thickening, which implies that a communication had existed, but that union had afterwards taken place. In only two instances could any thing like a laceration be detected in the lower part of the capsule; and even in these it could only be suspected from the thickness of the capsule in this part. In all the cases the capacity of the general capsule was much increased, and included within it more of the upper part of the humerus than natural. In two cases it distinctly allowed the head of the bone to be displaced from the glenoid surface of the scapula without the least difficulty.

"The fibro-ligamentous bands must be considered as the result of the organization of fibrine thrown out during the inflammatory stage consequent upon the first effects of the injury. The enamel-like or porcelain secretion may probably be traced to a similar cause, or looked upon as one of the resources of nature, to prevent parts subjected to unusual friction from being materially injured by such a process. In all the cases, (excepting Case II) the joints presented more or less of the fibro-ligamentous bands, and the enamel-like secretion immediately decides the question, which might otherwise have arisen as to the probable date of the injuries.

"It is likely that the first case was an example of the effects that may be expected to follow the dislocation into the axilla, with the addition of a rupture from its origin of the round tendon of the biceps muscle, which, according to the opinion of Sir Astley Cooper, is by no means to be considered a common circumstance, or generally attendant on this accident. It would seem to have been produced by a severe blow on the top of the shoulder, from the appearance of injury and fracture of the humeral extremity of the clavicle.

"The second case is probably one showing the effects of partial dislocation, in which the head of the humerus is drawn forwards against the coracoid process of the scapula, but quickly slips back again into its natural socket. It is an example of a rupture of the round tendon of the biceps muscle, instead of the tendon being torn away from its origin.

"The third case, I am inclined to think, has been a dislocation into the axilla or on the dorsum of the scapula: it exhibited the most serious injuries; the whole of the tendons of the muscles were torn away from their attachments.

"The fourth and fifth cases occurred in the same individual. I am at a loss to say in what manner the bone had been forced to produce the appearances observed, but I am inclined to think it probable that they are both examples of the dislocation upwards. I find that Sir Astley Cooper says, in his valuable work on Dislocations, 'It has been supposed that a dislocation of the os humeri upwards might occur, but it is obvious it could only happen under fracture of the acromion: it is an accident I have never seen.' In strength of the opinion I venture to offer in these examples, I find that the humerus may be readily displaced upwards when the acromion is fractured; so that the head of the bone rests on the superior margin of the glenoid surface, but immediately returns to its natural situation.

"It has been suggested, that the accident might have happened from the individual falling down stairs while the arms were half extended, or by any violence that would tend to throw the head of the bone forcibly upwards. It is a remarkable fact, that the appearances in one shoulder-joint should be nearly a counterpart of the appearances in the other; they would seem to have been produced at the same time, and both to have been followed by severe inflammatory symptoms, as evinced by the fibro-ligamentous bands and the secretion of enamel on the processes of bone. The motion between the fractured ends of the acromion was considerable, and each surface is invested with a layer of cartilage.

"The sixth and seventh cases likewise occurred in the same subject. The appearances in the right shoulder, I think, clearly indicate that it is an example of the effects of a dislocation under the pectoral muscle. The appearances of the left shoulder result, perhaps, from a dislocation under the pectoral muscle, or into the axilla. The curious coincidence, that both the long tendons of the biceps muscle should have remained displaced, and that both should present the same remarkable character, are facts worthy of being remembered; and the question occurred to me, whether the pain and inconvenience a patient feels in some cases for a considerable time after the reduction of a dislocated arm, may not be owing to the long tendon of the biceps muscle having been displaced from its groove, which would not only give pain by stretching that muscle but very considerably affect the action of the forearm? In this case I should think it right to give the arm a gentle rotatory motion after reduction, that the parts might thereby be properly replaced and adjusted to their wonted situations."

Those readers who attended the Cleveland meeting will find in the paper just quoted much that they heard from the platform and saw on the screen. Even the little silvery fibers, described by Gilcreest as binding the displaced tendon of the biceps to the sides of its groove, are mentioned here. So, also, are discussed dislocations of the biceps tendon which Meyer has so many times observed. As for my own impression that I was the first to call attention to ruptures of the supraspinatus and of the other short rotators,—it has been gently but firmly and permanently removed.

To those who wish to go to the dissecting room and see these defects for themselves, so that they may use their own judgment in deciding whether attrition or trauma was the cause, I should like to offer the following suggestions:

1. Do not dissect off the deltoid and turn it up to expose the subacromial bursa, as does Meyer and as did Smith 100 years ago, but make the incision which I recommend for operative exploration by separating the deltoid fibers over the greater tuberosity and opening the roof of the bursa. Hold the lips of the incision apart, while the humerus is rotated to make the whole base of the bursa visible in the incision. You will find the sac much larger than it appears when the deltoid is removed or lifted, for this necessarily destroys the flexible periphery of the bursa. If there is a complete rupture of the supraspinatus, you will not have to incise the base, but will see the defect at once and, if it is a large one, you will see the cartilage of the joint through it.

2. Having done this, remove the deltoid and observe how insignificant the base of the bursa appears now that its periphery is lost.

3. Now cut across the muscle bellies of all the short rotators back of

the glenoid and pull the distal portions of the divided muscles outward until their tendinous portions—which I call the musculotendinous cuff—cling to the capsule so tightly that they cannot be readily separated from it.

4. Next, cut the capsule around the inferior three-fourths of the glenoid and look into the joint and observe the origin of the long head of the biceps on the glenoid rim. If the joint is normal, you will have the opportunity to observe the points shown in Figure 1.

In the normal joint the synovial membrane is reflected from the edge of the cartilage at a precise line; there is no exposed bone in the sulcus. The opening of the bicipital groove is also precise and the long biceps tendon fits it as a finger does a ring. The pillars of this ring are composed of fibers of the tendons of the supraspinatus (outer) and the subscapularis (inner) and the tendon cannot possibly dislocate until a considerable number of these fibers are evulsed from their attachments. The more fibers of the subscapularis that are torn, the more the tendon can slip over the corner of the lesser tuberosity in external rotation of the arm, but a complete dislocation of the tendon cannot occur unless all, or nearly all, of the insertion of the subscapularis is torn, for some of its fibers bridge the groove and unite with those of the supraspinatus.

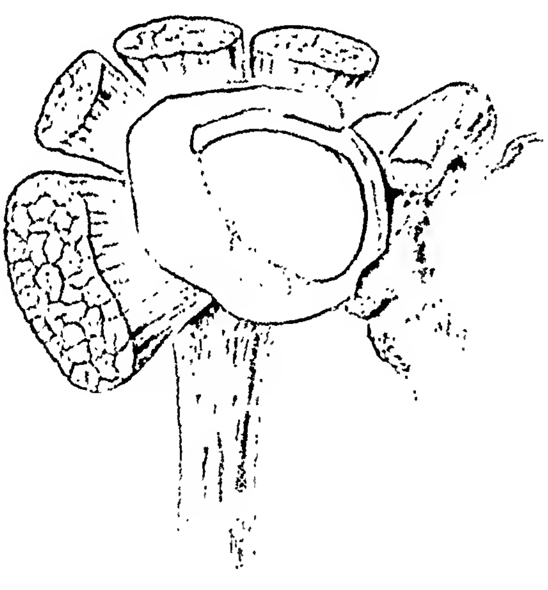

Fig. 1

Diagram showing the musculotendinous cuff. The inside of the joint is shown from the anterior aspect to indicate that there is *no sulcus in the upper half of* the anatomical neck and that in the lower half of the joint the insertion of the capsule is some distance from the articular rim. Here the bone is covered only by a thin layer of fibrous tissue and synovia.

The capsule has been cut just proximal to the line where it becomes welded into the musculotendinous cuff. In autopsy specimens one frequently finds bare bone between the attachment of the tendons and the articular cartilage, and such conditions are the end results of unrepaired ruptures of the tendon fibers. (*Reproduced from "The Shoulder" by the author.*)

Now, while all of this is true for a normal joint, it is difficult to find a perfectly normal one. Separation of some of the inner fibers of these tendons is the rule in most elderly subjects. Look for normal ones only in young cadavera. Even in these, as shown in Figure 2, you will usually find a few fibers evulsed. I speak of such lesions, where the nice reflection of the synovial membrane is torn away, as "rim rents", and I doubt if they ever heal in elderly tendons. I do not advocate operation on such lesions. I do advocate operation in cases of

Fig. 2

Photomicrograph, showing normal insertion of the supraspinatus tendon. Notice that a few of the minor fibers are ruptured even in this case. In the cadavera of most elderly subjects a considerable number of fibers will be found to have ruptured. (*Reproduced from "The Shoulder" by the author.*)

complete rupture, where the defect is large enough to make a communication between the joint and the bursa. I agree with Philip Wilson when he says that whether or not these defects are traumatic, they can be repaired.

If any reader contemplates operating on shoulder lesions, I earnestly urge him to study the anatomy after this manner on a number of cadavera before he attempts operation on living patients. Then, at operation on living patients soon after injury, he will be able to recognize these lesions before great retraction has occurred and the falciform edge alluded to has formed.

There are many minor points in this brief, reprinted paper which show keen observation,—for instance, "the enamel-like or porcelain secretion" which I take to correspond to what I call eburnation of the facets, and is found on the tuberosity and beneath the acromion in most long-standing lesions. We seldom use the word "secretion" in such a connection today. Smith noted the existence of fibroligamentous bands, as well as many of the changes in the biceps tendon that Meyer describes. In one minor point his observations, I am inclined to think, are more accurate than those of any of our present-day writers,—*i.e.*, the relative frequency of ruptures in the subscapularis *versus* those in the supraspinatus. If partial ruptures are to be included, the subscapularis perhaps leads, but complete ruptures almost always include the supraspinatus, no matter which of the adjoining tendons are also involved. Ruptures of the

subscapularis are very rarely complete, I have never found one at operation and only one in a cadaver.

Smith must have been a very interesting character, with a truly scientific bent, if we may judge by the following footnote on "keeping a dissecting-room journal", which appeared as part of the article quoted:

"We have been in the habit for some time past of keeping a dissecting-room journal, in which everything is entered that occurs out of the regular course, or differs from the natural appearance; the consequence has been that we have already collected a few interesting examples of varieties in the distribution of arteries and nerves, the absence of certain muscles, &c. If this plan were generally adopted in the dissecting-rooms in London, in the course of every session, a very curious and valuable collection might be made; the most interesting examples of which might be selected, and annually published in one of the medical periodicals."

One wonders if that journal has been continued by his successors. Perhaps we may account for the careful study which he made by his appreciation of the opportunity to study anatomical material secured by the exciting method alluded to in his first case.

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ROENTGENOGRAPHY OF TUBERCULOSIS OF THE JOINTS*

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It is common roentgenographic practice to produce films designed to show the bones only, the soft-tissue shadows being much too dark for intelligent study. Bone shadows are not particularly useful in *differential* diagnosis unless supplemented by soft-tissue shadows of effusion, swelling, infiltration, atrophy, relative density, etc., which are extremely useful. Changes in bone in most lesions come too late to really aid in the solution of the diagnostic problem. This leads to the erroneous conclusion that the roentgenogram is principally useful in showing the extent of the lesion and in confirming a clinical diagnosis which may have been made weeks or months previously.

Improvement in early differential diagnosis must start with the use of films which picture soft-tissue shadows properly. If the film fails to reveal clearly the fibrous texture of the subcutaneous tissues, the material is not the best for differential diagnosis in the extremities.

Assuming that films properly depict soft tissues as well as bone, what is the method of interpretation?

Lesions of the bones and joints may be classified almost at a glance as infections, tumors, calcareous degenerations, trophic lesions, or deformities. Infections involving bone reveal soft, hazy translucency about the bone lesion, due to increase of soft-tissue density within the bone, or they present subperiosteal calcifications of irregular texture and density which may hide the increase of soft-tissue density. When the bone is not visibly involved, the distribution, character, and outline of effusion and swelling are characteristic and the features of the other classes of lesions are absent. In tuberculosis, effusions and soft-tissue abscesses tend to be as dense as adjacent muscle shadows, sharply outlined, and centered on the lesion or elongated in the planes of the involved tissue.

The differentiation of tuberculosis from other infections is a matter of perceiving the characteristic expression of chronic and progressive development of effusion, soft-tissue atrophy, decalcification, and thinning of the cartilage space without productive calcifying reaction. One must see that these features are present in the degree and in the relation to each other which express the tendency to their chronic and progressive development. When this picture is evident, the lesion is probably tuberculous, but, before that diagnosis is made, it is necessary to consider the circumstances under which the lesion has developed. This is the only way to identify other infections which may imitate the picture of tuberculosis, or

* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons, Cleveland, Ohio, January 14, 1937.

FIG. 1

tuberculous lesions which may simulate other infections.

For example, a gonococcic lesion may imitate tuberculous arthritis. We will consider only a single feature of such a lesion,—the effusion. In gonococcic arthritis, effusion reaches the maximum within the first month and subsides in a few more weeks. Corresponding degrees of effusion occur in tuberculosis, but the duration is much longer,—twenty or thirty times as long. We have only to inquire as to the duration of the lesion to determine whether the amount of effusion present indicates tuberculous or gonococcic infection. This is consideration of the *circumstances* of the lesion. The duration of the disease has been used to indicate the proper choice of two possible interpretations of a given shadow.

The final diagnostic step is not concerned with the question, "Is this the picture of tuberculosis?" but with the question, "Is this the picture which tuberculosis would have produced in this particular patient under the particular circumstances of the lesion?"

Among the circumstances of the lesion which are important in the diagnosis of tuberculosis and which should, therefore, be known before attempting that diagnosis in a given case are:

1. The duration, which affects the amount of effusion, atrophy, decalcification, and thinning of the joint space particularly.

2. The previous treatment. Immobilization limits or reduces effusion and increases atrophy. Aspiration reduces effusion. Surgical procedures may alter the picture in various ways.

3. The age of the patient. Decalcification tends to be more prominent and more marked in children than in adults, but it may appear more quickly in the latter.

4. The virulence of the lesion. If the patient is not greatly affected by the lesion, atrophy and decalcification are less than when the functioning of the limb has been very much affected.

5. The presence of sinuses which may allow the development of secondary infection and the superimposing of pyogenic features on the tuberculous picture.

These are the more important circumstances of the lesion, consideration of which ordinarily serves to answer the question of diagnosis, but the more difficult the diagnostic problem the more necessary it becomes to know even more fully all of the circumstances of the case.

The illustrations indicate the similarity that may exist between tuberculosis and other diseases.

Fig. 2

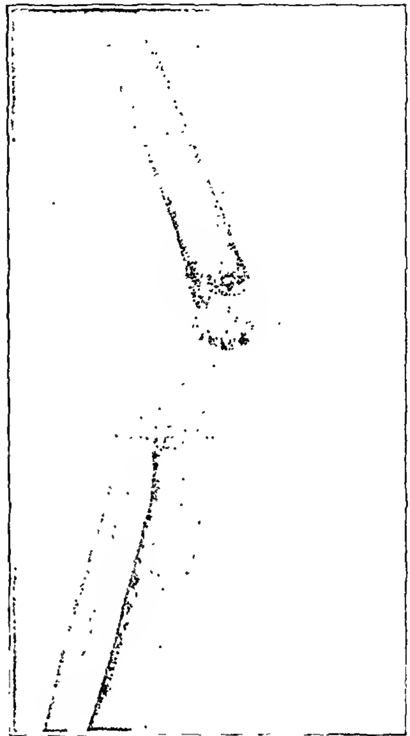

Fig. 3

In Figures 1, 2, and 3, each lesion presents a marked effusion without bone destruction or calcareous productive reaction,—a superficially similar picture. The illustrations are presented merely to emphasize this similarity. The differences cannot be truly reproduced in prints, but were detectable in the roentgenogram, on comparison with the opposite knee, as follows:

Figure 1 shows tuberculosis of six months' duration in a male, aged five. The effusion is dense and sharply outlined. There is no swelling beyond the capsule. The patella and epiphyses are overdeveloped. The cartilaginous joint space has not yet become thin. There is slight general decalcification. Soft-tissue atrophy is marked. The strongest suggestion that this lesion is tuberculous originates from the prominence of soft-tissue atrophy in proportion to the other changes in an untreated arthritis of six months' duration.

Figure 2 depicts rheumatoid arthritis of two and one-half years' duration in a female, aged eight. In spite of the long duration and the occasional fixation in plaster, there is no decalcification, the cartilaginous joint space is not thin, and soft-tissue atrophy is slight. In view of the circumstances, the lesion fails to express a tendency to chronic and progressive development of soft-tissue atrophy, decalcification, and thinning of the cartilaginous joint space. Tuberculous arthritis rarely exists as

FIG. 4

long as one year without thinning the joint space.

Figure 3 shows pyogenic arthritis, one month after onset, in a male, aged three. The joint was opened and drained for three days in the first week of the disease. The effusion is not so sharply defined because of the presence of slight swelling and infiltration, extending to the subcutaneous tissues. This represents a more active and acute process than tuberculosis and, consistent therewith, there is no atrophy and no decalcification as yet. The cartilaginous joint space has not yet become thin.

Figure 4 presents a picture such as might be simulated by subsided tuberculous arthritis. Actually, it is subsiding gonococcic arthritis of five months' duration in a male, aged thirty-nine. The time is too short for tuberculosis to arrive at this state. Persistence of marked local decalcification, particularly notable in the patella, indicates that there recently has been marked disturbance and hence the lesion has subsided rapidly.

There is no formula for the roentgenographic diagnosis of bone and joint tuberculosis. When there is a diagnostic problem to be solved, it is necessary to consider the prominence and relation of the various roentgenographic features to each other and to the circumstances of the case. While it is true that the expert may deduce the circumstances and history of the case from the roentgenogram with considerable accuracy, that ability is acquired only by a long period of study of the relation of the various pictures to the known circumstances. The simple way is to make available to the interpreter the facts which may have an influence on the degree of development of any of the various shadows present. Only when the interpreter has these facts and applies them properly to the films demonstrating the soft tissues will the diagnosis of bone and joint lesions reach full efficiency.

THE PRINCIPLES OF ORTHOPAEDIC AND SURGICAL TREATMENT IN THE RHEUMATOID TYPE OF ARTHRITIS *

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The problem of treatment of arthritis has been revolutionized in recent years by a more general recognition of the fact that it is one that demands a coordinated attack by members of a team and, particularly, the closest cooperation between physician and orthopaedic surgeon. Such teamwork can best be achieved in special Arthritic Units such as certain admirable ones in America, and in England that under the aegis of the London County Council at St. Stephen's Hospital, which works in coöperation with the St. John Clinic and Institute. The need for similar Arthritic Units in other large centers of population is urgent.

This problem is simplified by its consideration under:

1. The pre-arthritic stage;
2. The arthritic stage.

PRE-ARTHRITIC STAGE

Defective posture is, as Swaim and others have urged, an important predisposing cause of arthritis and may act in two principal ways. Let us take in the first place the common syndrome of round shoulders (kyphosis), exaggerated lumbar curve (lordosis), prominent abdomen, knock-knee (genu valgum), and pronated foot (pes planus). In such an individual the ribs are crowded together and the subcostal angle is acute. The diaphragm and chest wall function at marked mechanical disadvantage, with consequent interference with the normal function of the heart and lungs, and there is grave interference with the function of the abdominal organs, owing to the associated visceral prolapse. The effect upon the general circulation is serious and it is, therefore, not surprising that, in such cases of pronounced postural defects, the circulation of the extremities is impaired, causing the soil to be prepared for the onset of the arthritic seed. Secondly, it is commonly found, particularly in the spine and in the lower extremity, that arthritis supervenes in joints which have been subjected to undue strain for many years, owing to the presence of deformities due to defective posture.

There can be little doubt that the welcome interest that is now being shown by the authorities in many countries in the problem of insuring and maintaining the highest degree of physical fitness in all classes of the com-

* A lecture delivered at the St. John Clinic and Institute of Physical Medicine, London, England, March 19, 1937.

munity will bear a rich harvest and may well lead to a lowering of the incidence rate of many forms of rheumatic disease. It is to be hoped that the need for physical education will be brought home, not only to the youth of the nations, but to those who are no longer young. Many of the breakdowns of middle age, including doubtless many cases of arthritis, are due to a lack of observance of even the most elementary principles of physical well-being. It is, therefore, clear that the orthopaedic surgeon has an important rôle in schemes of physical training and in the prevention of many conditions which are predisposing causes of arthritis.

ARTHRITIC STAGE

Until comparatively recent years, a quite unjustifiable atmosphere of pessimism surrounded the treatment of arthritis. This attitude was reflected in half-hearted attempts to improve the lot of the arthritic patient, or even in a policy of *laisser faire*. Such patients were not regarded as "interesting cases", with consequences that were a reproach to Medicine. Although such patients are still often looked upon with disfavor at the large teaching hospitals, the excellent results that are now being achieved at special Arthritic Centers by the small band of enthusiasts who do in fact find arthritic patients "interesting" are at last bringing home to the profession the great possibilities of modern therapy in this vital branch of Medicine.

The orthopaedic and surgical treatment of the rheumatoid type of arthritis will be considered under two principal headings:

1. Prevention and treatment of deformity in the earlier and more acute stages.
2. Orthopaedic and surgical treatment in the later and more chronic stages.

PREVENTION AND TREATMENT OF DEFORMITY IN THE EARLIER AND MORE ACUTE STAGES

The deformities that occur in this stage are at first due to muscle spasm. It is usually found that flexion is a prominent feature because the more powerful flexors overcome their antagonists and because the patient often finds flexion of the affected joint to be the position of greatest comfort. In other joints, such as the shoulder and the hip, other deformities, such as abduction, adduction, or rotation, are combined with flexion, owing to spasm of particular muscle groups. In such early stages, if muscle spasm can be inhibited, the deformities can be corrected with comparative ease. After a fairly short period, however, these deformities, at first due to spasm, become "fixed", owing to actual shortening of the joint capsule and periarticular structures on the side of maximum contracture, and, in neglected cases, actual adhesion between the articular surfaces may occur by fibrous tissue or even by bone. The principles of treatment of the earlier stages may therefore be enumerated as follows:

1. In the acute stages, when muscle spasm is prominent, every ef-

fort should be made to prevent deformity; if necessary, light, easily removable splints may be used.

2. Our ultimate aim should be, wherever possible, to preserve a movable and functionally useful joint. However, the possibility of ankylosis is always present, so that the affected joint should be maintained in the "*optimum position*", if necessary in some form of light and comfortable apparatus which can be easily removed for local physical treatment.

3. When muscle spasm has already brought about deformed positions of the joints, these must be corrected at the earliest possible moment and before the deformities have become fixed. Table I shows the deformity which the untreated joint tends to assume and the corresponding optimum position.

TABLE I

CHARACTERISTIC TYPES OF DEFORMITY COMPARED WITH POSITIONS OF ELECTION FOR ANKYLOSIS (SPINE NOT INCLUDED)

Deformity	Position of Election for Ankylosis
Hand: Ulnar deflection of fingers at metacarpophalangeal joints. Well-marked flexion at interphalangeal joints; sometimes hyperextension at proximal interphalangeal joints.	Moderate degree of flexion at metacarpophalangeal and interphalangeal joints. Absence of lateral deviation.
Wrist: Flexion.	Extension through 45 degrees.
Elbow: Usually midway between flexion and extension; forearm in pronation.	Varies according to occupation and patient's wishes. Probably slightly less than 90 degrees is best. Forearm midway between pronation and supination.
Shoulder: Flexed, adducted, and rotated inward.	Slight flexion; abduction through 45 degrees (adults) or 70 degrees (children).
Foot: Hallux valgus or hallux rigidus. Toes deviated outward at metatarsophalangeal joints. Pronation at midtarsal joint, with consequent flat-foot.	The normal position. Slight inversion is sometimes advantageous.
Ankle: Plantar-flexed.	Foot forms an angle of 90 degrees with leg. A few degrees of dorsiflexion is sometimes preferable.
Knee: Flexed. In severe cases the tibia is subluxated backward and rotated outward.	Complete extension, although, if ankylosis is bony, a few degrees of flexion may be of advantage.
Hip: Flexed, adducted, and rotated inward (late stages).	Slight abduction and rotation outward in extension.

In recumbent cases, every effort must be made to avoid faulty posture. Many a neglected case is seen in which a prominent kyphosis has developed because the patient has been propped up with pillows. The hips and knees are frequently fixed in flexion, owing to the bad practice of placing a pillow under the knees, and the pressure of the bedclothes often causes the feet to be fixed in plantar flexion combined with valgus deformity.

Plaster-of-Paris

Various methods of splintage have been devised for the prevention of deformity and for its correction when due to muscle spasm. Some surgeons pin their faith upon plaster-of-Paris. This method requires extreme care in its application and it is of the utmost importance that, if plaster is used, the splint should be bivalved soon after its application, so that no undue pressure is caused and the joint is made accessible for physical treatment and gentle assisted movements.

No condemnation is too strong for the practice of immobilizing the affected joint in plaster for a long period, and no method is more likely to bring about irremediable ankylosis. Space will not permit a detailed description of the plaster-of-Paris technique, and those interested should consult the writings of Kindersley, Swaim, and others. The principles of the method can, however, be quite simply stated. Let us assume, for example, that we are dealing with the flexed arthritic knee. A plaster is first applied to the flexed and painful knee and bivalved laterally after a few days, so that the segments can be removed for effleurage, or heat therapy, or other forms of physical treatment. After a short period of rest in this position, it is usually found that spasm is so far diminished that a second plaster can be applied in an improved position. This process is repeated until the position of deformity is completely rectified.

Splints

The author has devised splints for both upper and lower extremities, which, in his opinion, banish many of the disadvantages of plaster. It is admitted that the splints involve a greater initial outlay than does plaster technique, but they have the advantages that they can be used repeatedly, they are simpler and more rapid in their application or reapplication, and there is less risk of interference with the circulation of the limb.

The "Universal" splint for the joints of the upper extremity is constructed of duralumin and is fitted with special types of universal joints at shoulder and elbow, which permit the shoulder or elbow to be fixed in any desired position. At the shoulder, for example, abduction, adduction, flexion, extension, and rotation can be altered as desired. Extension is possible in both arm and forearm pieces by extension slides. As constructed, the splint is applicable for arthritis affecting all the joints of the upper extremity, but the lower sections can be removed if necessary for application to the elbow or wrist.

The "Universal" splint for the lower extremity is constructed on somewhat similar principles and has been found valuable in the treatment of arthritis of the knee and ankle. An important feature is that the degree of flexion and extension at both knee and ankle and of abduction and adduction of the foot can be accurately adjusted.

Weight Extension

This is an alternative method and is sometimes of value, particularly in the case of the arthritic hip and when pain and spasm are marked. It is a method which requires close personal supervision by the orthopaedic surgeon and it should be remembered that, unless applied in accordance with correct mechanical principles, it may cause increased pain and muscle spasm. In the hip, for example, extension must be applied in the line of the thigh. If the weight extension is applied in the wrong axis, interosseous pressure at the hip is increased, causing increased spasm of the psoas and iliacus and often the development of lordosis.

Similar principles of deformity prevention are applicable to patients suffering from spondylitis ankylopoietica. In this disease, the need for prevention of deformity or for its correction in the earliest possible stages is most urgent. There is no more tragic sight than an exaggerated kyphosis which has been fixed either by very dense adhesions or by a bridge of bone connecting the vertebrae. Deformity can be prevented in these cases, and in the early stages it can be corrected by the application of the principle of extension in dorsal recumbency, either in a plaster bed or on a special mattress or Bradford frame. The normal forward convexity of the lumbar spine must be remembered and undue flattening guarded against.

ORTHOPAEDIC AND SURGICAL TREATMENT IN THE LATE AND MORE CHRONIC STAGES

Of the patients who, from the first, have had a more chronic type, many will be ambulatory, except when deformity or pain is very marked. Large numbers of such patients attend the St. John Clinic and Institute of Physical Medicine and the various forms of physical and medical treatment adopted have already been described in the series of lectures of which this is a part. In the treatment of these patients, close cooperation exists between the different departments, and its value can hardly be overestimated. Benefit is often obtained by employing in turn the various methods of physical treatment, and coordination between the medical and orthopaedic departments is of vital importance. Most of the methods of physical treatment—such as heat in its various applications, electricity, ultra-violet or balneological therapy—achieve their purpose best when combined with movements, especially in the form of carefully graduated exercises to strengthen the weakened musculature and to restore movement to the joints stiffened by the disease. In some cases, orthopaedic apparatus may be necessary, but, as far as possible, such methods are

avoided and indeed are often rendered unnecessary by modern treatment.

If undue mobility of a joint has been caused by destructive changes in the articular surface, as in the knee, some form of walking calliper splint may be necessary. The so-called "destressing" splints for arthritis of the knee or hip are, in the author's experience, of doubtful value.

The Use of Apparatus in Ambulatory Cases

In certain cases of arthritis, particularly in the weight-bearing joints such as the hip or knee, and when pain on exercise is a prominent feature, an attempt may be made to relieve intra-osseous pressure by some form of "destressing" apparatus to enable the patient to take exercise. Most of this apparatus is constructed after the pattern of the Thomas splint. In applying extension to the hip or knee, the principal *point d'appui* above should be the ischial tuberosity. The lateral steel supports are made a little longer than the limb and terminate in right-angled pieces that fit into the heel of the patient's shoe. The patient's heel is separated by a short space from the inner surface of the heel of the shoe, so that, in standing or walking, extension of the limb and separation of the sensitive joint surfaces are brought about. A locking device can be introduced at the level of the knee joint to enable the patient to sit in comfort.

Is it mechanically possible, however, to separate the joint surfaces in this way in an ambulatory form of apparatus, and, even if it is possible, is not any such attempt based upon an erroneous conception of the cause of the pain in these cases?

Treatment of Deformity in the Later Stages of the Rheumatoid Type of Arthritis by Manipulation

The treatment of these deformities by manipulation is, in suitable cases, of great value. Success in this highly specialized branch of orthopaedic work necessitates a long period of training, without which its use is fraught with great difficulties and even dangers. The unqualified condemnation which this method of treatment formerly received in textbooks on Medicine is, however, unjustifiable when the "forced movements" to which they refer are replaced by gentleness and skill. Textbooks wisely warn their readers about the violent reaction in the joint and the shock that may follow the use of undue force in performing manipulation, but both of these untoward results are extremely rare in the experience of those who have specialized in manipulative work. Manipulation of a stiffened arthritic joint should never be performed when any signs of active disease are present either in the stiffened joint or in other regions. If there is any doubt upon this point, the sedimentation rate should always be ascertained. Roentgenographic examination is a necessary preliminary, as cases showing marked destruction of the articular surfaces or dense intra-articular ankylosis, either fibrous or bony, are obviously unsuitable. Joints with minor degrees of stiffness often improve markedly

with various methods of physical treatment. The latter should in such cases, therefore, be given a fair trial, and only in the event of their failure should manipulation be considered. It should be remembered, however, that a suitably performed manipulation may obviate long periods of physical treatment and may thus save much time and energy and relieve the strain upon departments of physiotherapy.

The stretching or breaking down of adhesions is of necessity a painful process, and an anaesthetic should always be administered. Occasionally, slight cases of adhesions can be manipulated under local anaesthesia or gas in the out-patient department or consulting-room. In most cases, however, it is more satisfactory to admit the patient to a hospital or a nursing home, so that proper preparation can be carried out and a general anaesthetic given. Sodium evipan, given intravenously, is a valuable anaesthetic for cases of slight or of moderate degree.

One of the most important factors of success in manipulative work consists in a policy of gradually restoring movement by a carefully planned series of manipulations. In this way, reaction in the manipulated joint can usually be completely avoided. In straightening a flexed knee, for example, the limb is temporarily fixed after manipulation in some easily removable splint in the improved position attained by the first manipulation. The splint is removed daily for physical treatment, including active movements. After a week, or possibly a little longer, a further manipulation is performed and the splint is reapplied at the altered angle. This process is repeated until complete extension is restored. Similar measures are adopted for increasing the flexion of the knee, should this be restricted, or for increasing the range of movement of other joints.

As previously mentioned, plaster casts may be used instead of splints, provided the casts are bivalved at the earliest possible moment to allow access to the limb for treatment. The greatest care must always be taken to avoid undue force in performing any manipulation, especially in a case of arthritis, for it must be remembered that in these cases the bone is often atrophic and liable to fracture.

RHEUMATOID ARTHRITIS OF THE WRIST JOINT

The orthopaedic aspects of the treatment of the rheumatoid type of arthritis which have been described may now be briefly summarized by applying them to the treatment of various degrees of the rheumatoid type of arthritis of the wrist joint.

Early Stages

The tendency to drop-wrist, owing to the more powerful action of the flexors of the wrist, must be borne in mind. This may sometimes be prevented, when spasm is not a prominent feature, by gentle daily movements, both active and assisted, but, if spasm is pronounced, a light cock-up splint should be worn, which, if necessary, can be so adjusted as to

keep the thumb and fingers extended. This splint should be removed daily for gentle movements, as fingers that have become fixed in extension are even more useless than those that are partially flexed.

The author prefers a light, well-fitting, and easily removable metal cock-up splint for this purpose. If plaster is used, the splint should be bivalved within twenty-four hours, so that sections can be removed daily for the necessary movements of the wrist and the fingers. As the acute symptoms subside, the splint can be discarded for a few hours daily and later it may be discontinued during the day but worn at night before being discarded altogether. In an acute case, if drop-wrist due to muscle spasm has already occurred, this deformity must be gently overcome before the cock-up splint is applied. When painful spasm is very marked, an anaesthetic may be necessary.

Chronic Type

The treatment of a more chronic variety of the rheumatoid type of arthritis of the wrist joint will now be discussed. No actual deformity is present, but the movements of the joint are restricted by 25 per cent., and a fair trial of various forms of physical treatment has been made. In such a case, manipulation under some such anaesthetic as gas and oxygen or intravenous sodium evipan is indicated. No form of retention splint is necessary, and active and passive movements are commenced immediately and maintained regularly.

Neglected Case

We will now discuss the treatment of a neglected case of the same type of arthritis in which drop-wrist of the "fixed" type has developed. In such a case, a series of manipulations at intervals under anaesthesia is indicated. The actual number of manipulations will depend upon the degree of stiffness, and preliminary roentgenography is always necessary to ascertain the state of the articular surfaces. At the first manipulation, it may be advisable to rest content with gaining 25 degrees of extension. A palmar splint is applied, which maintains the wrist in the corrected position, but the splint should be removed within twenty-four hours for active and passive movements, preceded by radiant heat or infra-red treatment. At the end of a week or ten days, it will probably be found that the patient is able to extend the wrist through the increased range, and a second manipulation may be performed and the power of extension of the wrist still further improved. The palmar splint is adjusted accordingly and the after-treatment continued as before, and in a short time the power of complete active extension at the wrist joint is obtained. The palmar splint is then adjusted in such a way that the wrist is kept fully extended. It should be worn both day and night at first and then left off for gradually increasing intervals during the day and finally discarded altogether. Similar principles are applicable to the orthopaedic treatment of other joints.

SURGICAL OPERATIONS IN ARTHRITIS OF THE RHEUMATOID TYPE

There can be little doubt that, with a more general recognition and observance of the principles of physical and orthopaedic treatment in the earlier stages of arthritis, and with closer cooperation between medical and orthopaedic departments, the number of advanced cases of deformity, for which surgical operation is required, will steadily diminish. Until this ideal state of affairs has been established, however, such operations will continue to play a valuable and important rôle in the treatment of carefully selected cases of arthritis, particularly in the later stages. Surgical operations in arthritis may be divided into those which aim at fixation or ankylosis of the affected joint and those which endeavor to retain a movable joint. As a general rule, in cases of advanced arthritis, ankylosis in the optimum position is aimed at in the weight-bearing joints of the lower extremity where stability is a principal consideration.

Excision of an arthritic joint is indicated when pain is severe and resists other measures and is associated with marked destruction of the articular surfaces. In the case of the knee, after removal of the articular surfaces, ankylosis in the optimum position is deliberately sought, but, in the cases of the hip, the shoulder, the elbow, and the metatarsophalangeal joint of the great toe, the ultimate aim is usually a movable joint.

Arthrodesis aims at the production of ankylosis in a joint and is most often performed upon the hip joint when pain is intolerable and resists other measures. When it is satisfactorily performed and bony union is secured, relief from pain in the affected hip is obtained. The operation is a severe one and it is often contra-indicated by the age and general condition of the arthritic patient. This operation should never be performed without a previous thorough and patient trial of modern methods of physiotherapy and particularly of manipulative treatment.

Osteotomy is necessary when osseous ankylosis has occurred in a bad position. This operation is valuable in cases of ankylosis of the shoulder or hip in marked adduction.

Arthroplasty is an operation that is at present on trial in the treatment of arthritis. With further study and technical improvement, it may prove to be of great value. The indications for its performance are cases of bilateral ankylosis, such as stiffness of both hips, elbows, or knees, or combinations of ankylosed hips and knees.

Posterior capsulotomy is of value in cases of obstinate flexion deformity of the knee, which have proved resistant to manipulation, in which the roentgenogram shows slight or moderate changes in the articular surfaces, and in which it is clear that the obstruction to extension is due to contracture of the posterior portion of the capsule of the knee joint.

Synovectomy is a valuable operative procedure in suitable cases. It is particularly indicated in cases of the rheumatoid type of arthritis of the knee joint, in which the disease affects principally the synovial membrane and in which can be palpated enlarged and tender synovial villi which, by

becoming squeezed between the articular surfaces, give rise to recurrent attacks of pain and effusion.

Removal of loose bodies is sometimes necessary. In the later stages of the rheumatoid type, secondary osteo-arthritic changes may supervene, with formation of osteophytes. Occasionally such osteophytes may become detached and give rise to recurrent attacks of locking, necessitating their removal.

Arthrotomy and lavage is a method which, in the author's experience, has proved valuable in subacute arthritis of the rheumatoid type. It has proved of greatest value in the case of arthritis of the knee, mainly involving the synovial membrane, which has proved resistant to other methods of treatment. A small incision is made upon the inner side of the knee, any enlarged synovial fringes in the vicinity are removed, and the joint is thoroughly irrigated with Dakin's solution. In many cases, the symptoms clear up in a remarkable manner, and the improvement is permanent.

CONCLUSIONS

In conclusion, it may be stated that the great advances that have been made in recent years in the treatment of arthritis by physical, orthopaedic, and surgical measures and the equally important advances in the purely medical treatment have revolutionized our outlook upon this scourge of mankind and justify us in replacing the former pessimistic attitude by one of guarded optimism.

JOINT CHANGES RESULTING FROM PATELLAR DISPLACEMENT AND THEIR RELATION TO DEGENERATIVE JOINT DISEASE * †

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In a previous investigation [6] concerning the repair of articular cartilage in the knee joints of dogs, marked intra-articular changes similar to those of degenerative joint disease [2] ‡ were observed in all joints in which the patella had become permanently displaced. (See Figures 1, 2, 3, 4, 5, and 6.) Since similarly operated joints in which the anatomical relations of the patella to other joint structures were maintained showed no important intra-articular changes, we concluded that the observed degenerative and hypertrophic changes in the articular cartilage had resulted because of the patellar displacement.

The present study was undertaken to determine the effects of patellar displacement in knee joints which had not been opened surgically or traumatized in any other manner, and to compare the changes produced with those found in human knee joints with displaced patellae.

FIG. 1

Roentgenogram of the right knee joint of a dog in which the patella had become displaced twelve weeks earlier. The joint was enlarged, marginal proliferation had taken place, and numerous joint mice had formed. Note the position of the patella in relation to the femoral condyle.

METHODS

Owing to the difficulties encountered in maintaining patellar displacement in the unopened knee joints of dogs, it was found necessary to carry out the present study on rabbits.

Operation: Under ether anaesthesia and with sterile surgical technique, a small incision was made just medial to the infrapatellar ligament of one knee joint. The superficial fascia was divided

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‡ The synonyms commonly employed are hypertrophic arthritis, osteo-arthritis, and degenerative arthritis.

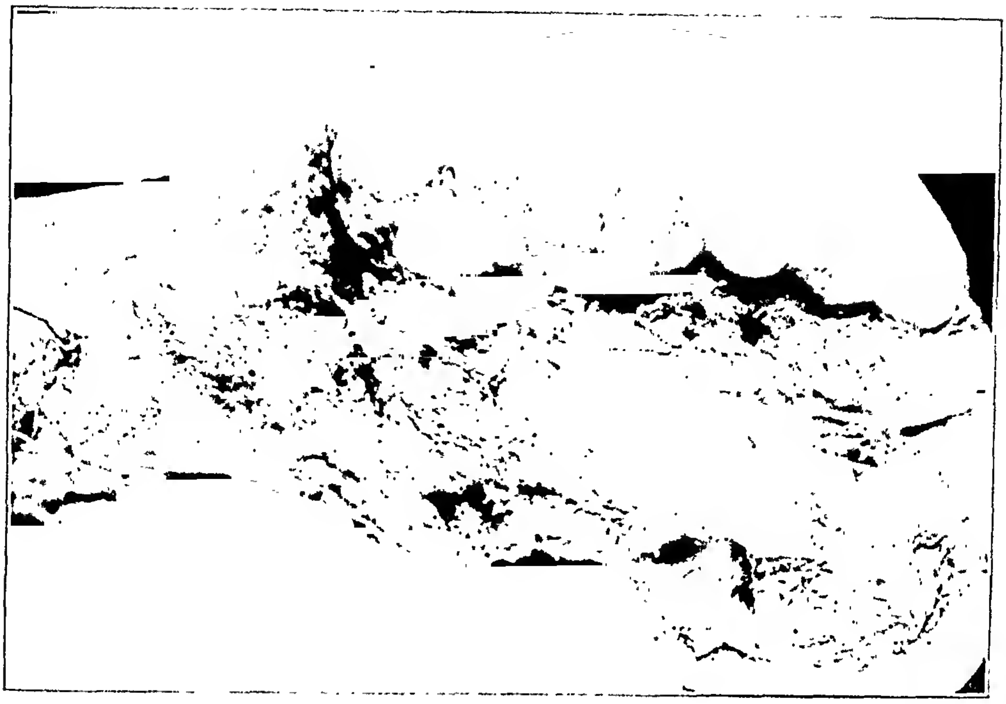

FIG. 2

Gross specimen (× 2). Marked marginal lipping of the femoral articular surface had taken place in this dog joint after the patella had been displaced for a period of twelve weeks. (*Courtesy of the American Journal of Pathology.*)

and reflected, so as to expose the patellar and internal lateral ligaments. A chromic catgut suture (No. 1) was then inserted through the middle portion of the patellar ligament. Traction upon this suture lifted the patella forward, so that it could be easily dislocated to the inner side of the medial ridge of the patellar surface of the femur. To insure permanent displacement, the suture was then passed through the internal lateral ligament

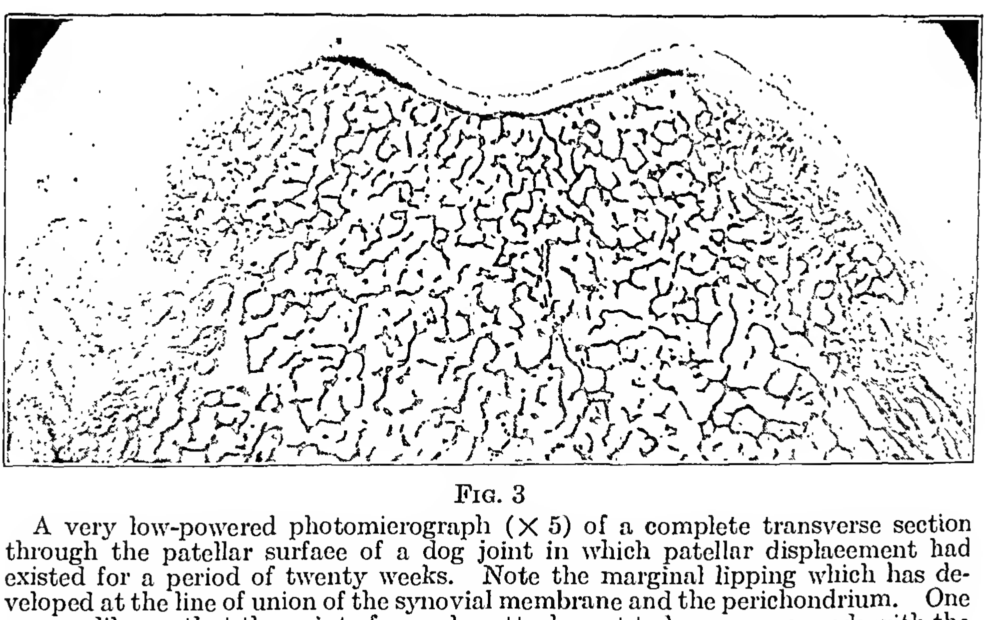

FIG. 3

A very low-powered photomicrograph (× 5) of a complete transverse section through the patellar surface of a dog joint in which patellar displacement had existed for a period of twenty weeks. Note the marginal lipping which has developed at the line of union of the synovial membrane and the perichondrium. One can readily see that the point of capsular attachment to bone corresponds with the areas of greatest overgrowth.

and tied. The fascia and skin were closed in layers with sutures of silk and a collodion dressing was applied. The opposite knee joint served as the control. Eleven animals were so treated.

Postoperatively each animal was confined to a cage, no attempt being made to restrict motion in the operated joint. Slight swelling at the operative site, an obvious limp, and limitation of motion persisted for from two to five days. Following this, the animals hopped about in a normal manner, although two of them continued to exhibit moderate limitation of motion. A few weeks later, in each case the operated joint was found to be wider than its control and the lateral articular margins felt irregular on palpation.

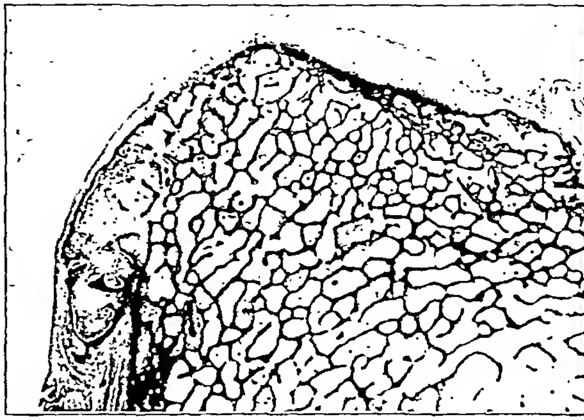

Fig. 4

Photomicrograph (× 5). Pronounced proliferative changes had taken place at the point of capsular attachment to the articular margin in this dog joint after a four-week period of patellar displacement.

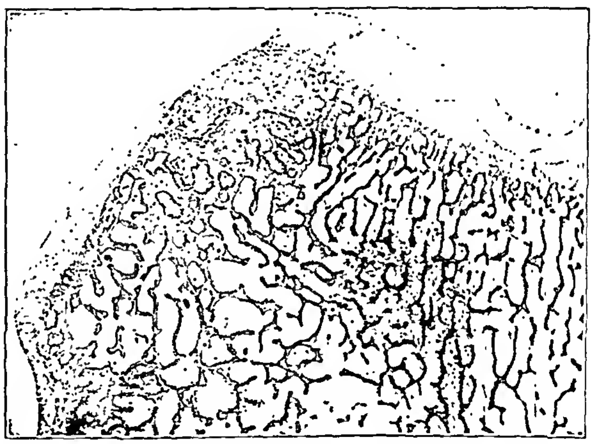

Fig. 5

A low-power photomicrograph (× 5) of the femoral articular surface of a dog joint, showing an area from which the articular cartilage had been worn away by the displaced patella. Marked condensation and polishing (eburnation) of the exposed subchondral bone had taken place. Below this point may be seen marginal overgrowth (lipping) where the synovial membrane of the joint capsule is reflected onto the articular margin. Patellar displacement had existed for twelve weeks.

The animals were sacrificed under ether anaesthesia at intervals of four, eight, twelve, and twenty-eight weeks following patellar displacement. The knee joints from each rabbit were removed, partially opened, and immersed in a 10-per-cent. solution of formaldehyde. After thorough fixation, they were completely opened, examined, and photographed. Blocks of tissue were removed from representative areas of each joint. The soft tissues were embedded in paraffin. The tissue blocks containing bone were decalcified in a 5-per-cent. solution of nitric acid and em-

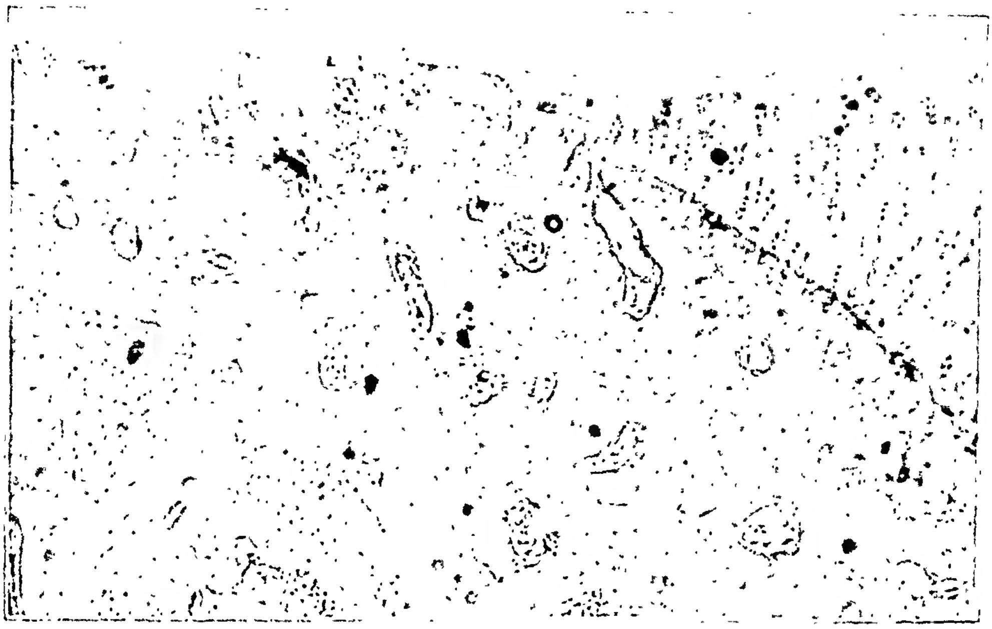

FIG. 6

Photomicrograph (× 64), showing an area of eburnation from the joint illustrated in Fig. 5. Note the endosteal activity which has resulted in the condensation of the subchondral bone.

bedded in celloidin. All microscopic sections were stained with hematoxylin and eosin.

MACROSCOPIC APPEARANCE OF THE JOINTS

All joints with displaced patellae were irregular in contour and wider (twenty-two to thirty millimeters) than their controls (nineteen to twenty millimeters). The average increase in width for the total series was five and four-tenths millimeters. There was no increase in synovial-fluid content. The chief intra-articular changes noted were degeneration of the articular-cartilage surfaces and hypertrophy of the articular margins.

Figure 7 illustrates the intra-articular changes which ensue following patellar displacement of four weeks' duration. There may be noted a newly formed patellar groove medial to the inner patellar ridge, slight elevation of the lateral articular margin, and marked atrophy of the articular cartilage of the patellar groove of the femur. The latter was so marked over the epicondylar ridge that the underlying red subchondral bone was readily seen. The articular cartilage of the patella showed no gross changes. The synovial membrane appeared slightly thickened with beginning villus formation. The joint was six millimeters wider than its control. The increased width appeared to have resulted from proliferation of the synovial membrane, the perichondrium, and the underlying bone on the medial side of the femoral condyle at the point where the synovial membrane is attached, thus providing a new articular surface for the displaced patella.

More marked marginal proliferation of the articular cartilage of both patellar ridges was observed after eight weeks of patellar displacement.

In addition, depressed areas, from which the cartilage had almost completely disappeared, were seen on the articulating surface of the femur. The displaced patella rested in a recently formed groove (similar to that shown in Figure 7) consisting of newly formed cartilage and underlying bone. This new patellar groove accounted for the five-millimeter increase in width of the femur. Although the articular surface of the patella appeared normal, the synovial membrane about it was slightly hypertrophied.

The intra-articular changes resulting from twelve weeks' patellar displacement were similar to those previously mentioned. In one instance the patella was only slightly displaced, resting on the inner side of the medial femoral condyle. The constant movement of the patella over this area resulted in complete disappearance of the femoral articular cartilage in two places, measuring approximately two by three millimeters. Moderate marginal lipping of the lateral femoral condyle had occurred. In another joint in which the patella had been completely displaced for this same period of time, the observed changes were much more marked. (See Figure 8.) The femur was ten millimeters wider than its control. The large, recently formed patellar groove was covered in its deepest portion by irregular, pitted, frayed cartilage. The original femoral articulating surface was dull and roughened in appearance. The elevated nodular condyles were very similar to those seen in the degenerative joint disease of the human. The patella was partly obscured by surrounding hypertrophied villi. The changes in the synovial membrane were more marked in this joint than in any other in the series. The patellar cartilage was undergoing degenerative

Fig. 7

Photograph (natural size) of the left and right knee joints of a rabbit, with patellar displacement of four weeks' duration in the left joint. Note the atrophy of cartilage on the femoral articular surface and the newly formed patellar groove on the medial femoral condyle.

FIG. 8

Photograph (natural size) of the right and left knee joints of a rabbit in which the patella of the left joint had been displaced twelve weeks earlier. The joint is markedly widened. The articular margins of the femur are elevated and overhanging. Two joint mice had formed and there was moderate hypertrophy of the synovial membrane.

changes as shown by its dull, pitted, uneven surface. Two small round joint mice, measuring four by three millimeters by one millimeter and one and five-tenths millimeters by one by one millimeter, were found in the quadriceps pouch.

The alterations in the knee joint after twenty-eight weeks of patellar displacement (Fig. 9) were not unlike those just described, except that the synovial membrane showed less evidence of hypertrophy.

Upon sacrificing one animal with supposed displacement of the patella of twenty weeks' duration and two animals with displacement of twelve weeks' duration, no intra-articular changes were noted and the patellae were found in their normal positions. These findings indicated that the sutures had not held, thus allowing the patellae to return to their normal positions soon after displacement. The absence of intra-articular changes in these and the control joints would seem ample evidence that the previously described degenerative and hypertrophic changes resulted solely from the displacement of the patella and the intra-articular derangements which follow.

MICROSCOPIC EXAMINATION OF THE JOINTS

The chief changes noted in the sections from these joints were those of degeneration of articular cartilage, proliferation of the tissues at the perichondrial margins of the articulating surfaces, and slight to moderate proliferative changes in the synovial membrane. These changes as observed in the dogs are readily seen in Figures 3 and 5. The changes encountered in the rabbits are well illustrated in Figures 11, 12, and 13 and

should be compared with the normal (Fig. 10).

The most marked intra-articular changes following four weeks of patellar displacement were observed in the articular end of the femur (Figs. 7 and 11). The cartilage over the medial condyle was much thinner than normal. In other areas, there was noted fibrillation or superficial depressions and pitting, in which multiplication of cartilage cells had taken place. Marked reconstruction of the femoral condyle was apparent. This had resulted from proliferation of the connective tissue at the junction of the synovial membrane, periosteum, and perichondrium. This proliferating tissue had increased in thickness, the deeper layer having been transformed into cartilage which, in turn, was undergoing ossification by means of endochondral ossification. There was slight marginal lipping along one side of the patella, and its articular surface showed slight fraying and pitting. The synovial membrane was slightly thickened in certain areas and the capillaries and small blood vessels were dilated.

FIG. 9

Photograph (natural size) of the right and left knee joints of a rabbit in which patellar displacement had existed in the right knee joint for a period of twenty-eight weeks. The affected joint is greatly widened and deformed. The original articular cartilage of the femur has almost entirely degenerated and marginal overgrowth has occurred along both the medial and the lateral perichondrial borders.

After eight weeks of patellar displacement, the changes noted were very similar to those just described but more extensive. (See Figure 12.) The recently formed patellar groove projecting from the medial condyle was covered by a thick layer of fibrocartilage. In its deepest portion, the cartilage had assumed a columnar arrangement, similar to that seen in an epiphysis, and was undergoing endochondral ossification. One zone of proliferating cartilage, resembling an epiphyseal cartilage plate, was observed between two recently formed areas of bone. In addition, there was noted almost complete disappearance of the articular cartilage over

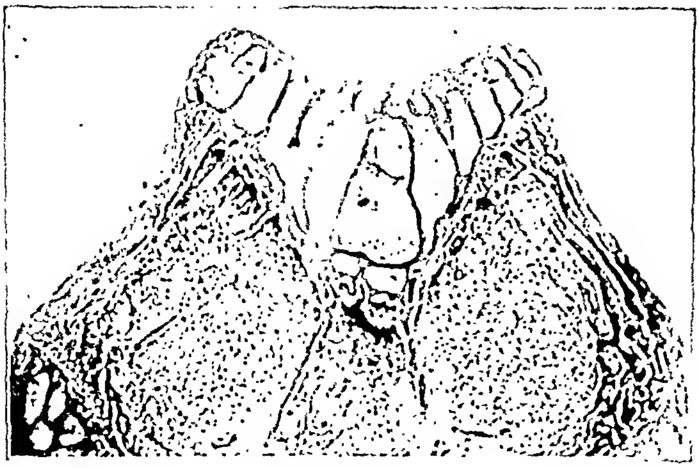

Fig. 10

Photomicrograph (× 5) of section from a normal knee joint of a rabbit, showing the articular surface of the femur. This section and those illustrated in Figs. 11, 12, and 13 are from approximately the same levels. In this rabbit the lower femoral epiphysis is ossified.

the medial epicondylar ridge. The underlying bone was more dense because of increased endosteal activity. The synovial membrane and subsynovial tissues showed dilatation of the small vessels and slight infiltration of the tissues with lymphoid and mononuclear cells.

In the twelve-week specimens, the medial marginal lipping was more advanced, the articular cartilage was thinner, and the calcified zone of cartilage was disrupted in several places. Bone formation was observed in the synovial membrane some distance from the femoral condyle. The synovial membrane was moderately hypertrophied, very hyperaemic, and covered with fibrin in certain regions.

After twenty-eight weeks of patellar displacement, the original articular femoral cartilage had almost completely disappeared. (See *Figure 13.*) The subchondral bone was exposed through wide gaps in the calcified zone of cartilage. The marginal lipping of the medial femoral condyle consisted of dense, well-formed, and orderly arranged bone trabeculae supporting the newly formed articular surface which consisted for the most part of fibrocartilage. Fibrillation and degeneration of this imperfect articular cartilage had taken place. Sections from this joint and the previous ones indicated that the

Fig. 11

A cross section through the patellar surface of the femur is shown in this low-power photomicrograph (× 5). Note the atrophy and splitting of the articular cartilage and the marked new bone formation on the medial condyle beneath the newly formed patellar groove. This bony overgrowth has resulted from endochondral ossification of the proliferating connective tissue at the point of reflection of the synovial membrane onto the periosteum and perichondrium. Note that the deeper layer of newly formed connective tissue has acquired the arrangement of an epiphyseal cartilage. The epiphysis is open and growing in this joint.

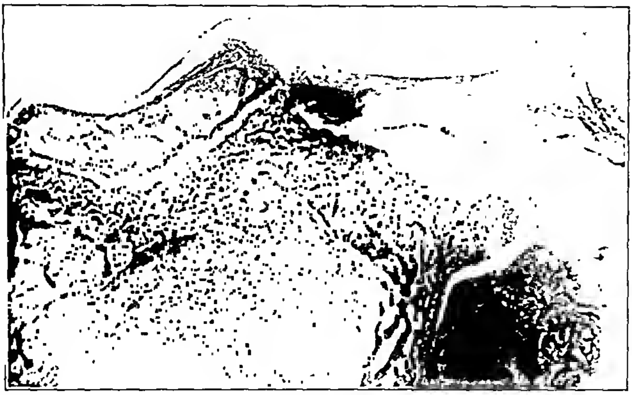

FIG. 12

Photomicrograph (× 5) like that in Fig. 10, showing more pronounced reconstruction of the femoral end after patellar displacement over an eight-week period.

FIG. 13

Photomicrograph (× 5) similar to Figs. 11 and 12, showing almost complete destruction of the original articular surface of the femur at the left. The proliferative changes previously illustrated have resulted in the formation of a new articular surface covered by imperfect fibrocartilage which is supported by dense but well-ordered bone. Patellar displacement existed for twenty-eight weeks in this joint.

marginal lipping had resulted because of proliferation of the connective tissue at the perichondrial border of the articular surfaces, with subsequent differentiation into cartilage and replacement by bone. Irregular bony excrescences had occurred elsewhere in this joint because of a similar but uneven proliferative activity.

From these observations, it is apparent that the chief characteristics of degenerative joint disease—namely, degeneration of articular cartilage, condensation of subchondral bone, and marginal lipping—do occur soon after displacement of the patella. That similar intra-articular changes develop at an early age in the human knee joint as a result of patellar displacement is well illustrated in the following case.

CASE REPORT

Mrs. H. L. M. (M. G. H. No. 320,382), thirty-seven years of age, entered the Hospital because of recurring pain in the knees. This symptom had first been noted at the age of twelve. The patient stated that the knees became dislocated if she turned her ankle, tripped, walked on rough ground, or turned suddenly. She had always been able to replace the displaced patellae. Following such displacement, the knees had been swollen, tender, stiff, and painful on walking, for a period varying from a few days to a week. Such dislocation had recurred frequently up to the age of twenty-three. She then remained practically symptom-free up to the age of thirty-six, except for occasional swelling of the knees, due to lateral displacement of the patellae. During the year prior to hospital entry, the condition recurred repeatedly in the right knee. She finally entered the Hospital because of increasing pain and disability of two months' duration.

Physical examination was essentially negative, except for the knees and under-

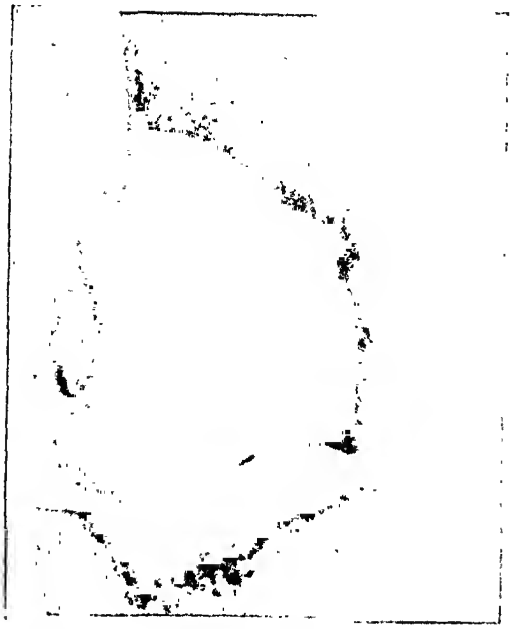

Fig. 14-A

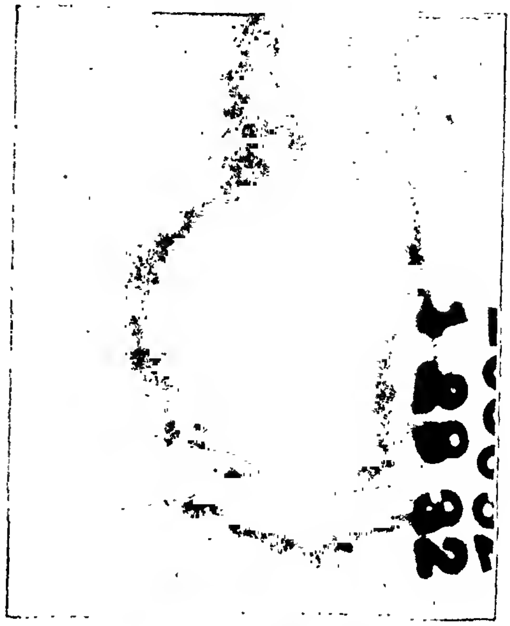

Fig. 14-B

Fig. 15-A

Fig. 15-B

Roentgenograms (anteroposterior and lateral) of the left and right knee joints of a woman, thirty-seven years old, who, since the age of twelve, had been subject to repeated displacement of the patellae. This anatomical derangement had occurred more frequently in the right joint where the degenerative joint changes were more advanced.

nutrition and dental caries. Examination of the lower extremities revealed moderate bilateral genu-valgum deformity and pronated feet. The knees were moderately enlarged, the right more than the left, because of synovial-membrane thickening and increase in size of the infrapatellar fat pads. No fluid was demonstrable. The patellae were displaced laterally and tilted posteriorly. The internal femoral condyles were unduly prominent. Joint motions were accompanied by marked crepitus, but were not painful except when the knees were flexed beyond 90 degrees on the right and 110 degrees on the left.

Routine blood and urine examinations were negative. Both the Wassermann and the Hinton tests were negative.

Roentgenograms revealed marginal proliferation of the condyles, more marked on

the right. Marginal proliferation of the patellae was also present, again more marked on the right. Two large masses and one smaller one, having the appearance of bone, were demonstrable in the right quadriceps pouch. (See Figures 14-A, 14-B, 15-A, and 15-B.)

The right knee was opened through a median parapatellar incision. The synovial membrane lateral to the patella appeared thickened. The masses described were easily found. The smaller one was lying free; the two larger masses were attached to the overhanging lateral margins of the patella. The articulating surfaces showed marked degenerative changes and considerable marginal lipping. There was an area of eburnated bone on the lateral condyle beneath the patella. The synovial membrane was resected, and the masses and thick bony excrescences from the upper lateral margin of the patellar surface of the femur were removed.

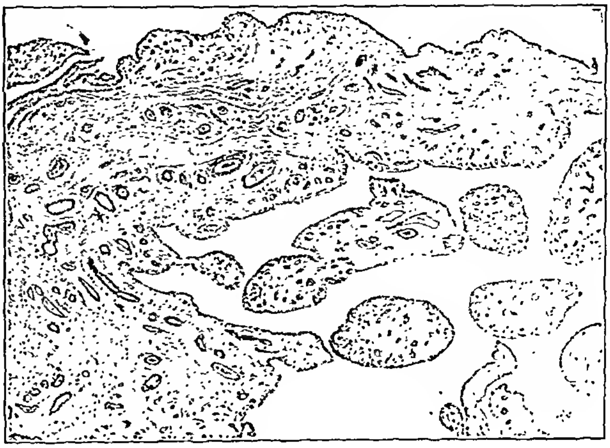

FIG. 16

Photomicrograph (× 20) of the synovial membrane from the right joint illustrated in Figs. 13 and 14-B. Although moderate villous hypertrophy has occurred, there is no sign of active inflammation.

Microscopic examination: The synovial membrane from the quadriceps pouch showed no great variation from the normal. The villi, which were slightly larger and somewhat more numerous than those seen in a normal joint of a person of the same age, were covered by normal-appearing layers of synovial-lining cells. Scattered mononuclear leukocytes and lymphoid cells were present, but polymorphonuclear leukocytes were rarely observed. Definite pathological changes were present in the thickened synovial-lining tissue obtained from an area lateral to the patella. Numerous, fairly large, and often branching villous projections were noted. (See Figure 16.) These consisted of vascular and somewhat oedematous connective-tissue cores bounded by a few poorly defined layers of synovial-lining cells. There was no significant inflammatory cell infiltration in any of the sections examined. Sections from the overhanging margins of the articular surfaces of the patella and the femur were examined. (See Figure 17.) These osteophytes or spurs consisted of cancellous bone surrounded on the upper and outer surfaces by uneven hyaline cartilage, showing considerable fibrillation of the matrix and

FIG. 17

The extent of the marginal lipping is demonstrated in this photomicrograph (× 5) of a bony excrescence projecting from the articular margin of the patellar surface of the femur.

uneven distribution of cartilage cells. The surface zone of such cartilage was pitted, frayed, and, in places, covered by layers of spindle cells which had the appearances of proliferating fibroblasts. Portions of these osteophytes were bounded by compact bone. Such areas were, in turn, covered by vascular connective tissue, the surface layers of which were not materially different from synovial-lining tissue. Again, no signs of inflammation were observed.

Sections through the bony masses removed from the joint showed them to consist of bone and cartilage, each of which was surrounded by a zone of proliferating fibrous tissue. Histological study of numerous sections indicated that the sequence of events in the growth of these bodies was as follows: proliferation of connective-tissue cells at the periphery, differentiation of such cells and the intercellular substance into hyaline cartilage, and, finally, the calcification of much of the cartilage thus formed. Several areas in the interior of the loose bodies showed cystic degeneration. There was no positive evidence to indicate the origin of these loose bodies by detachment of the marginal osteophytes described.

DISCUSSION

Since there is difference of opinion as to the exact manner in which the intra-articular changes of degenerative joint disease are produced, it seems desirable to discuss in detail the development of such intra-articular changes resulting because of a lone joint abnormality,—namely, patellar displacement.

That degenerative and proliferative changes in the cartilage, similar to those of degenerative joint disease, can be produced experimentally has been demonstrated by Kroh and Wehner. Kroh attributed the changes following resection of one femoral condyle to the incongruity of the joint surfaces. Wehner concluded that the abnormal use of the joint, following patellar resection, was an important factor in the production of the resulting intra-articular changes. Our experimental findings lend support to such conclusions, but are in disagreement with those of Key who concluded that simple resection of a small piece of cartilage from the patellar groove was of itself an adequate cause for such intra-articular changes. Resection of articular cartilage or of cartilage and subchondral bone is not the cause of intra-articular pathology unless coincidental displacement of the patella or some additional injurious factor results because of the operative procedure [5, 6, 7]. Ely and Cowan were unable to produce hypertrophic arthritis by cauterization of the articular cartilage, as previously described by Axhausen, and were forced to conclude that such changes were the result of faulty technique and extensive damage by the electrocautery.

The degenerative and hypertrophic changes in cartilage observed in the present experiments, following simple patellar displacement, were most marked in the joints in which the abnormality was greatest or had existed for the longest time. As in human degenerative joint disease, the first change noted was that of degeneration of the hyaline cartilage [12], appearing on the epicondylar ridge which had articulated with the displaced patella. (See Figures 5 and 6.) In these same joints, the cartilage of the non-articulating femoral patellar surface showed progressive signs of atrophy similar to the atrophy of disuse previously described [6, 8, 9].

(See Figures 7, 9, and 13.) These findings and observations on so-called normal human knee joints of various ages [3] suggest that the nourishment and maintenance of normal cartilage is dependent in part on adequate lubrication by synovial fluid, which, in turn, is best maintained by normal articular apposition and use. They further suggest that undue pressure and friction [4] or absence of normal articular apposition will lead to accelerated articular-cartilage degeneration. These changes occur more rapidly in those areas where the ability of articular cartilage to repair itself is most limited [5, 6, 7].

In certain of these joints, the continued pressure and friction of the displaced patella resulted not only in the complete loss of the articulating cartilage but also in condensation or eburnation of the underlying exposed subchondral bone. (See Figures 5 and 6.) Such condensation of bone was evidently due to stimulation of the endosteum. It was never observed until the articular cartilage was completely eroded. Although the non-articulating surfaces of such joints revealed areas in which equal or greater degrees of articular-cartilage degeneration had taken place, there was never any evidence of eburnation of the underlying bone. (See Figures 9 and 13.) This and similar findings demonstrable in human knee joints would seem adequate evidence that undue pressure and friction produce sufficient stimulation of the endosteum to bring about condensation of the subchondral bone.

The changes in the synovial membrane in certain of these experiments were more marked than is ordinarily observed in degenerative joint disease. Such synovial-membrane hypertrophy and villus formation were also observed in the case herein reported. Loose bodies of cartilage, or of cartilage and bone, may be encountered in degenerative joint disease. Their exact mode of formation is not always certain. They may represent detached fragments of the marginal lipping or metaplastic transformation of hypertrophied synovial villi. They were encountered only in one experiment in this study.

One of the most characteristic roentgenographic features of degenerative joint disease, as observed in the human, is the marginal overgrowth or lipping (osteophytes and spurs). Although this marginal overgrowth is looked upon as secondary to the primary degenerative changes [3, 12] its production has never been adequately explained. Parker, Keefer, Myers, and Irwin concluded that such bony projections occurred in deranged joints, usually after flattening of the joint surfaces had taken place. They state that, because of such flattening of the joint surfaces, the marginal bone and cartilage are forced outward and downward, or, if depressions exist in the marginal articular cartilage, the projections may be forced upward. Such an explanation would seem adequate in the case of the extensively altered joints of older people, but it does not explain the varying forms and degrees of lipping observed in younger individuals [3]. In this age group, one notes increasing prominence at the point demarcating the junction of the synovial membrane and the periphery of the articular

surface before any significant flattening of the joint surfaces is demonstrable. With increasing age, this zone becomes increasingly more prominent and in many instances progresses to fully developed lipping.

In these experiments and in those previously done on dogs (Figs. 3, 4, and 5), it was noted that the earliest detectable marginal proliferation occurred at the point where the synovial membrane reflects onto the perichondrium of the articular margins. This marginal zone is very vascular and possesses greater reparative and proliferative ability than do the avascular central areas. That the tissues in this region are subjected to frequent stress and strain can be readily demonstrated by examining a partially opened joint. On doing so, one notes that extension and flexion of the joint result in alternating tension and relaxation of the synovial membrane at its insertion. This oft-repeated tension would seem to serve as sufficient stimulus to this vascular fibrous tissue to cause it to proliferate. Such proliferating fibrous tissue (perichondrial and periosteal) being in intimate contact with bone and cartilage may become differentiated into fibrocartilage or hyaline cartilage and bone. Once these proliferative changes have taken place, sufficient alteration in the normal mechanics of the joint may ensue to allow the changes to progress more rapidly. Anatomical alterations—such as genu valgum, genu varum, and patellar displacement—undoubtedly greatly increase the stress and strain in this region and, in consequence, there results a more rapid and more extensive marginal proliferation. In one experiment a new articular surface had developed in as short a time as four weeks; whereas, in another, in which the displacement was of twelve weeks' duration, the new articular surface was supported by well-arranged bone trabeculae. (See Figures 11, 12, and 13.) The direct pressure of the displaced patella on the underlying tissues undoubtedly is in part responsible for the newly formed patellar groove.

From these studies it is apparent why extensive degenerative joint disease may develop in relatively young individuals with any type of patellar displacement. This being the case, corrective treatment should be instituted sufficiently early to prevent the development of irreparable joint damage.

These studies further indicate that the increased wear and tear to which a joint is subjected as a result of a lone joint abnormality (patellar displacement) is of itself an adequate cause for extensive degenerative joint disease. In these experiments, one can feel quite certain that the intra-articular changes represented a local disease process and not a manifestation of some systemic infectious, metabolic, or endocrine disease, because the control joints showed no intra-articular abnormalities. The changes encountered can be accounted for on the basis of several factors: (1) undue pressure and friction, causing loss of cartilage and eburnation of bone; (2) absence of normal intra-articular apposition and, in consequence, of normal lubrication by the synovial fluid, with resulting cartilage degeneration and atrophy; and (3) undue tension of the synovial membrane

at the site of its attachment, with resulting proliferation of the underlying fibrous connective tissue which, undergoing changes, results in marginal proliferation. This additional evidence lends support to the theory that degenerative joint disease may, in most instances, represent nothing more than the changes due to wear and tear, resulting from increasing age and long-continued daily use. Such changes, due to wear and tear secondary to long-continued use, are much more marked in the case of articular cartilage than of other body tissues because this cartilage has a limited source of nourishment and a very limited ability to repair itself.

SUMMARY

1. The patellae of rabbits can be displaced without opening or otherwise injuring the knee joint. Such patellar displacement is of itself adequate cause for degenerative and hypertrophic changes in cartilage, similar to those of degenerative joint disease.

2. The undue pressure and friction of the displaced patellae resulted in rapid loss of the underlying articular cartilage with subsequent eburnation of the subchondral bone.

3. The absence of normal patellar apposition and, in consequence, of lubrication of the non-articulating surfaces with synovial fluid was responsible for articular-cartilage degeneration and atrophy.

4. Proliferation of the connective tissue at the perichondrial margins of the articular surfaces led to well-defined marginal overgrowth. This marginal overgrowth was sufficiently marked to form a new patellar articulating surface on the medial side of the femur.

5. The repeated stretching of the synovial membrane at its insertion, coincident with full extension, would seem adequate stimulus to cause the very vascular, undifferentiated, perichondrial connective tissue to proliferate sufficiently to result ultimately in marginal lipping. Such marginal proliferation occurs to some degree in all joints with increasing age and long-continued use, but develops much more rapidly in joints with anatomical derangements such as patellar displacement.

6. The clinical and pathological findings from one patient with bilateral displacement of the patella were identical with those of degenerative joint disease.

7. These studies emphasize the importance of early corrective measures in patients with displaced patella if irreparable joint damage is to be prevented.

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OS ACROMIALE—A CONTESTED ANOMALY*

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Some time ago the writer was called in by the Compensation Commissioner to express an opinion in the case of a longshoreman, thirty-eight years of age, who had sustained an injury to one shoulder. It was the author's duty to ascertain whether a certain fracture of the acromion, as seen in a roentgenogram, was recent or old. After studying the film, it was decided that both shoulders should be x-rayed in the supero-inferior position before a decision was made.

The writer was then able to point out to the Commissioner that:

1. There was no difference whatever in the outline of the bony gap (the alleged fracture line) between the terminal end of the acromion (pre-acromion and meso-acromion) and the basal part of the acromion (meta-acromion and basi-acromion) in the injured and in the non-injured shoulder.
2. The bony gap was in the same direction and plane in both shoulders.

The diagnosis was bilateral os acromiale, not due to an injury.

The Commissioner accepted this diagnosis, but the plaintiff's physician could not be convinced that this gap in the acromial process was due to non-ossification of the intervening cartilage. At that time the author could not refer him to roentgenographic evidence on this subject in the English literature. Since then, other contested cases of similar nature have arisen and it has been possible to show, through an English translation of Köhler's book, a reference to the roentgenographic appearance of the os acromiale. It is because of the paucity of material on this subject in the English literature that the author is reporting twenty-five cases of os acromiale found in a study of the routine roentgenographic examinations of 1800 shoulder girdles.

In reviewing some of the literature on this subject, one is impressed by the tenacious views held by Struthers and his school,—namely, that a division line in the acromion is a form of ununited fracture; even the bilateral appearance, he explained, is due to fractures, not necessarily simultaneous.

In opposition to this view, Bernardeau in his thesis on this bone shows, by a comparative anatomical study, that such a separate bone formation might exist as an atavistic trait, having found it present in the sorex and in the chrysochloris.

Anatomists are at present more disposed to the view expressed by Bernardeau. Gray states: "Failure of bony union between the acromion

* Approved for publication by the Surgeon General, United States Public Health Service.

and the spine sometimes occurs, the junction being effected by fibrous tissue or by an imperfect articulation; *in some cases of supposed fracture* of the acromion with ligamentous union, it is probable that a detached segment was never united to the rest of the bone." Cunningham states that "failure of union" [of the different ossifying centers of the os acromiale] "may, however, persist throughout life". In a later edition, this author goes further and adds: "The greater part of the acromion is *throughout life a separate bone*, united to the rest of the bone by periosteum and a strip of cartilage or by a synovial joint which appears like a line of fracture in the x-ray photograph; the condition is usually alike on the two sides."

The frequency of this anomaly, as reported by anatomists, varies to such an extent as to warrant belief that their divergence of opinion is based on their different concepts of the nature and appearance of an os acromiale. Hence, McAllister reported an incidence as high as 15 per cent.; Pfitzner, in a group of personally examined cases, gave the frequency as 7 per cent.; and Gruber found only three cases in 100 cadavera. In Gruber's report, however, it must be noted that he excluded all forms which did not have a distinct joint with synovial membrane.

Roentgenographically, there is even greater dissent. Lilienfeld, reporting on 200 shoulder-girdle examinations in the anteroposterior (sagittal) plane, found none. Köhler did not come across any in his thirty-one years of experience; whereas Becker, in 160 cases, examined 240 shoulders both in the anteroposterior (sagittal) and in the axial planes and found four cases of unilateral and one case of bilateral *atypical* os acromiale.

Our 1800 shoulder-girdle examinations, made in the anteroposterior and the oblique positions, disclosed *twenty-one typical* and *four atypical* cases of os acromiale. Since we used the axial examination only in contested cases, it is quite possible that we missed a few cases of the atypical type.* From the practical viewpoint they were not disturbing, hence, not significant. With the addition of the axial examination as a routine, these smaller or atypical types might also become contested cases; but then the differential diagnosis is more obvious.

To appreciate further the varieties of this anomaly, we should acquaint ourselves with the development of the acromion. According to Folliasson and Neumann, at about the fifteenth to the eighteenth year, there appear three separate ossifying centers at the epiphysis of the acromion: a pre-acromion, a meso-acromion, and a meta-acromion (Fig. 1). The fourth, or basi-acromion, is a continuation of the center for the scapula which appears at about the third month of foetal life. At about twenty-two to twenty-five years of age, these centers fuse with the base

* Since the original study of these 1800 shoulders, 1000 more cases have been followed. Each time that a diagnosis of os acromiale was made, the patient was called for reexamination and the other shoulder girdle was examined in the usual anteroposterior and also in the inferosuperior positions. There were twenty-seven cases of os acromiale observed. Only twenty-one patients came back and of these thirteen had bilateral and eight unilateral os acromiale. The frequency is 2.7 per cent., nearly 62 per cent. being bilateral.

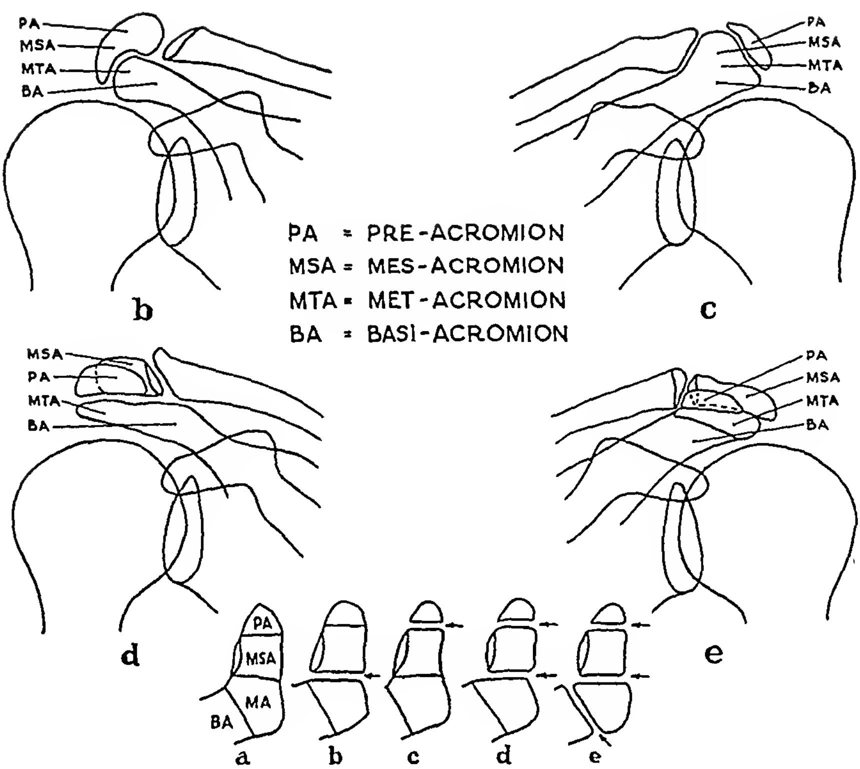

FIG. 1

Diagram representing the different ossific centers which constitute the adult acromion. *PA* = pre-acromion; *MSA* = meso-acromion; *MTA* = meta-acromion; and *BA* = basi-acromion. The earliest center is that of the basi-acromion which is a continuation of the center for the body of the scapula, appearing at about the third month of foetal life. One, two, or three bony centers appear almost simultaneously at about the fifteenth to the eighteenth year and fuse together to the basi-acromion at about twenty-two to twenty-five years of age. Failure of union may occur between the pre-acromion and the meso-acromion, between the meso-acromion and the meta-acromion, between the meta-acromion and the basi-acromion, or a combination of any two or even all centers. The most common non-union is between the meso-acromion and the meta-acromion. In regard to the other centers, the pre-acromion is fused to the meso-acromion and the meta-acromion is fused to the basi-acromion as in *b*. This constitutes a typical os acromiale. Any other location of failure of union, as in *c*, *d*, and *e*, is atypical. (Redrawn from Folliasson.)

of the acromion. When there is failure of union of any one of these centers to its neighbor, the resulting separate bone is an os acromiale; hence, the four possible forms of os acromiale. The most frequent form is union of pre-acromion and meso-acromion, union of meta-acromion and basi-acromion, but separation between meso-acromion and meta-acromion. (See Figure 1, *b*.)

Bernardeau and Symington described the existence of a distinct joint cavity in this most frequent form, with capsular ligament and synovial membrane lining the joint cavity. In twenty-four cases, Bernardeau found twenty with diarthrodial and four with amphiarthrodial types of joints. Symington observed that the younger a person is,

the greater is the possibility for the interacromial joint to have its medial end included in the acromioclavicular space. The older the person is, the less is this possibility.

Anatomically, the os acromiale has been classified under four principal types. The most frequent is the *quadrangular;* next, the *oval;* third, the *triangular;* and, rarely, the *falciform.* Since the anatomical classification of the acromion is based on its appearance as viewed from *above,* whereas the common roentgenographic examination is based on the *anteroposterior* (sagittal) view of the shoulder, the precise details of the anatomical appearance will not be studied here. It must be remembered that this anteroposterior roentgenogram of the shoulder is neither a true coronal cross-sectional nor a sagittal cross-sectional view of the acromion as seen in the anatomical superior view; therefore, these types can only be approximated roentgenographically. In doubtful cases, the anatomical view may be reproduced by taking an inferosuperior view (Berent and von Hecker), which is an axial view of the shoulder girdle seen roentgenographically.

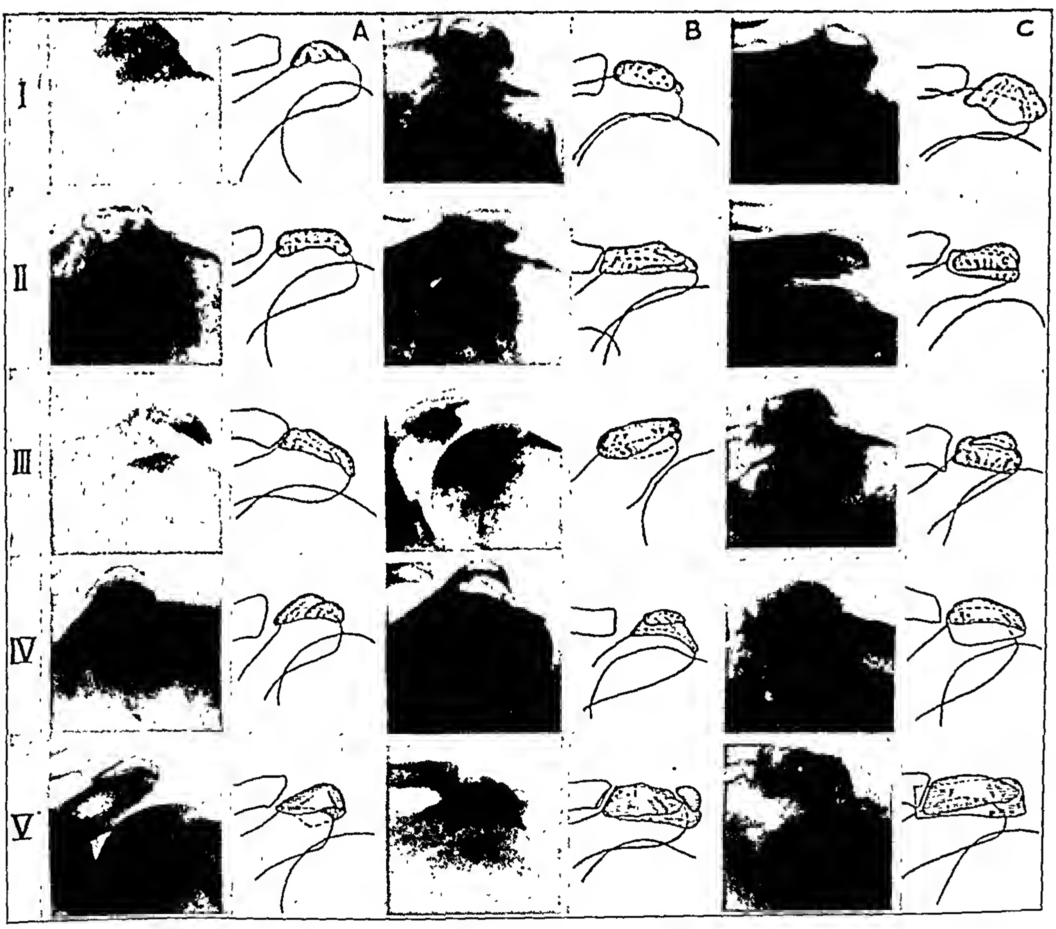

Fig. 2

In this figure are represented fifteen different sizes or forms of os acromiale as seen in the anteroposterior views. On the right of each view is its sketch to facilitate better visualization of the separate superimposed "bonelet", os acromiale, on the acromion.

Since the material for this study consisted of the usual antero-posterior and oblique views of the shoulder girdle, our description of the os acromiale is primarily based on its roentgenographic appearance as seen in the first of these two views. It is well to remember that the direction of the central ray determines the roentgenographic appearance of the upper peripheral border of the acromion, and hence the type will vary with deviation of the direction of the central ray. This principle can be demonstrated by the fact that the quadrangular type may appear slightly *ovoid* or more *flattened*, depending on whether the central ray has been directed lower or higher than the glenoid cavity.

ROENTGENOGRAPHIC FINDINGS

The roentgenographic appearance of the os acromiale is not uniform because irregularity in shape, size, position, and mode of articulation with the clavicle is due to the random chance formation of this bone. Nevertheless, in this study, it has been found that certain recognizable factors recur with sufficient frequency to justify a topographic description and nomenclature for the os-acromiale shadow as seen roentgenographically.

In Figure 2, the roentgenograms of fifteen different types of os acromiale are given, each being supplemented by a drawing, intended to facilitate the visualization of the os acromiale as an entity. The left shoulders are shown in reverse position to facilitate arrangement. The ages of the patients ranged from twenty-eight to seventy-five years, the average age being forty-seven years. In all of these cases, the os acromiale is seen as a separate shadow, roughly triangular in shape, varying in size*, and appearing to sit unevenly astride the angle of the acromion. The transverse axis is about three times as long as the vertical diameter, and is usually tilted inward for about 15 degrees from the horizontal toward the upper lip of the crest of the spine. The density of the upper half of the shadow is the same as that of the lateral end of the clavicle; the lower half shows two dense lines with or without a darker linear shadow between these two lines. The upper line is horizontal and represents the basal part of the acromion which is continuous with the spine at the angle where the crest and the lateral border of the spine meet; the lower line is oblique, upward, and outward, and represents the basal part of the os acromiale which has failed to fuse to the rest of the acromion. This line is lower because of the overlapping of the shadow of the os acromiale on the acromial shadow. There may be more than two lines, as in atypical cases, but there must be *at least two;* otherwise, each downward projected

* The shape and the size of the os acromiale vary depending upon whether non-fusion took place between pre-acromion and meso-acromion, meso-acromion and meta-acromion, or meta-acromion and basi-acromion. In the most common form of separation found (between meso-acromion and meta-acromion (Fig. 1, *b*) the size of the os acromiale varies from one centimeter in length, one-half a centimeter in width, and three-quarters of a centimeter in height to two and one-half centimeters in length, three centimeters in width, and three-fourths of a centimeter in height. The following descriptive names have been given to the different shapes observed in Figure 2: Hemispheric, *A-I;* Plane, *A-II*, *A-III;* Toque, *A-IV*, *B-II;* Helmet, *A-V*, *B-IV*, *B-V*; Cube, *B-III*, *C-I*, *C-II*, *C-III*, *C-IV*, *C-V*.

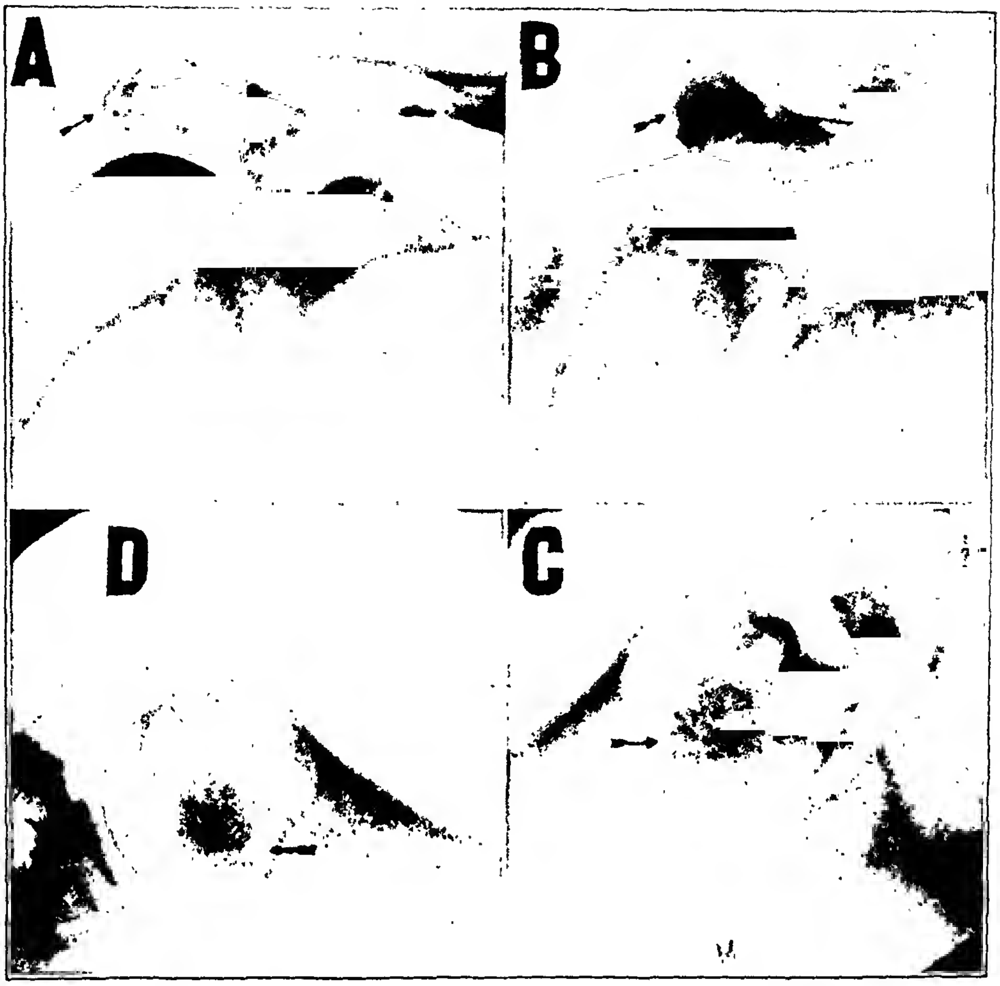

FIG. 3

Appearance of a typical os acromiale in the three different views: (*A*) the ordinary anteroposterior, (*B*) the oblique, and (*C*) and (*D*) the inferosuperior of both sides. This patient was a man, thirty-two years of age, who had sustained an injury to the right shoulder as the result of a fall. In *A* there is a suspicious linear shadow, shown by the arrow. In *B*, the linear shadow is more prominent, and a separate bone, cone-shaped, can be discerned. However, in *C*, it is evident that the separate piece of bone is separated from the rest of the bone by a uniform band of non-osseous tissue; the borders are not sharp, nor are they ragged. The same findings are also present in the other shoulder (*D*).

acromial end would be taken for an os acromiale. The median border is sharply linear and denser, usually parallel to the adjacent long diameter of the clavicle, forming with it a *joint space between the os acromiale and the clavicle.* The superior border is convex, continuous with the medial border internally.

DIFFERENTIAL DIAGNOSIS

The problem of deciding between a fracture and an os acromiale can be resolved by the following salient factors:

1. *Bilaterality* occurs in about 62 per cent. of the cases of os acromiale.

2. The *borders* of the problematic shadow are *rounded* and the

cleavage line is *uniform* in the case of an os acromiale, whereas the *borders* are *sharp* and the *cleavage line* is *ragged* in the case of a fracture.

3. The *position* of the shadow is at the same or at a higher level than the remaining part of the acromion in the case of an os acromiale, whereas the *position* of the shadow is at a lower level in the case of a fracture.

To these three factors may be added the fact that pointed borders indicate associated osteo-arthritis. Also, fractures of the acromion are less frequent, only ten cases having been found in the examination of 1800 shoulder girdles; the majority of these were associated with other minor fractures or dislocations of the shoulder girdle.

SUMMARY

Roentgenographic examinations of 1800 shoulder girdles, made in the sagittal plane, disclosed twenty-one typical and four atypical cases of os acromiale. At least six of these cases have been contested as being possible fractures. An additional study of 1000 cases gave a frequency of 2.7 per cent., 62 per cent. being bilateral. A supero-inferior examination facilitates the making of a differential diagnosis.

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LESIONS OF THE LUMBOSACRAL SPINE

PART II. CHRONIC TRAUMATIC (POSTURAL) DESTRUCTION OF THE LUMBOSACRAL INTERVERTEBRAL DISC

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The roentgenographic appearance of this lesion is shown in Figure 1.

Under this grouping fall all mechanical alterations of the low spine, which cause an uneven distribution of weight on the intervertebral discs. This results in an early pathological degeneration of that portion of the disc which is under abnormal stress. Due to the structure of the lumbosacral region and to the erect posture of man, this stress is exerted only on the posterior and lateral margins of the lower spinal discs.

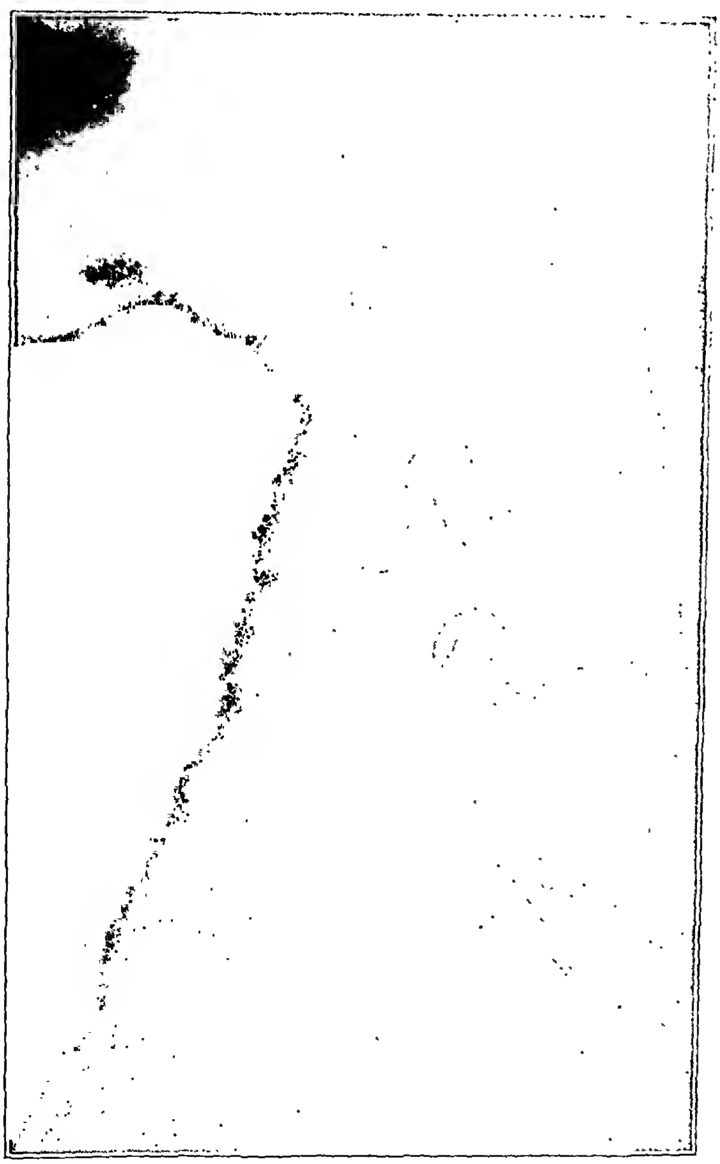

FIG. 1

Chronic traumatic or postural destruction of the lower lumbar and lumbosacral intervertebral discs (retouched). Note the subluxated facets and constricted foramina.

Etiology

A lateral tilt of the first sacral vertebra, due to a short leg, or to hemiatrophy, or to a congenital malposition of this segment, is the most common cause of increased pressure on the lateral aspect of the lumbosacral disc. Such a condition causes a lateral tilt of the sacral table. If the spine were a rigid structure, which moved with the first sacral segment, a deviation of the entire trunk toward the low side would result. This would severely disturb

the center of gravity of the body in its relationship to its base of support. Since the spine is a flexible column, the center of gravity is maintained over its base of support by flexing the spine laterally toward the long extremity. This results in an abnormal stress on the lateral aspects of the lumbosacral and lower lumbar intervertebral discs.

A lumbosacral lordosis is the common cause of pressure on the posterior margin of the lower lumbar and lumbosacral intervertebral discs.

Posture is undoubtedly responsible for the vast majority of painful backs. The assumption that at least 60 per cent. of all persons past the age of forty years are potentially subject to pain in the lower part of the back the author believes is justified. That many persons escape is due to the lack of physical exertion and strain at this site.

Provided that the pull was slight and exerted over a period of many months, it would undoubtedly be possible to extend a metacarpal phalangeal articulation until the finger contacted the dorsum of the hand. The pain experienced from such a procedure would no doubt be of low grade and aching in character. However, if at any time during the course of such a procedure a sudden increased force was applied, severe pain would follow, which would require several days to subside. If there was a nerve so situated that it would be compressed as extension was continued, the person would experience pain throughout the distribution of that nerve.

A similar situation is constantly taking place in the lumbosacral region of the spine. The sacrospinalis group of muscles are continually in action when a person is moving about in the erect position, thus exerting a constant extensive force on the low spine. As a result of the sedentary life of most adults, the weakened abdominal muscles continue to get weaker from disuse, while their antagonistic sacrospinalis muscles continue to get stronger from overuse. This permits a protrusion of the abdomen which tends to shift the weight forward and thus to disturb the center of gravity. This disturbance in the center of gravity is compensated for by increasing the extension of the lumbosacral spine, thereby shifting the weight of the thorax posteriorly. During this process there is a constantly increasing force being exerted on the posterior margins of the intervertebral discs of the lower lumbar and the lumbosacral regions. The discs become wedge-shaped in appearance and a subluxation of the joints formed by the articular facets is evident by roentgenographic examination, as shown in Figure 1.

If, at any time during this process of extension of the lumbosacral spine, a sudden increased extensive force is applied, severe symptoms in the form of pain in the lower part of the back will follow. The mechanics involved in such an injury is a sudden increase in the degree of subluxation of the articular facets. They have violated what Brown has described most clearly and has spoken of as the "Factor of Safety Motion".

After the extensive force has been continued long enough to permit the posterior margins of the vertebral bodies to approximate one another closely, the foramina are so constricted that an irritation of the funicular

portion of the nerve results and pain is experienced throughout the distribution of that particular nerve.

The two principal types of postural backs which cause an increase in the lumbosacral lordosis are those commonly spoken of as the round hollow and the round.

It is the writer's opinion that the kinesiological action involved in bringing about such postural deformities is the same in both types; the difference in the deformities is dependent upon constitutional types.

The round back is most commonly seen in patients who present a relaxed attitude. They are usually inclined to be thin. Their joints are loosely constructed and hyperextension of elbows, knees, and hips is a common finding. They present a poor muscle tonus and give the impression of a disturbance or imbalance of the internal glands of secretion. The feet and hands are usually long and narrow, as is also the thoracic cage. The thoracic and abdominal viscera present findings characteristic of their constitutional types. These have been described by Goldthwait.

The round hollow back is most commonly seen in patients who are inclined to be obese. Their joints are firmly constructed and frequently are found to fall a few degrees short of complete extension. They present a good muscle tonus and are inclined to be more energetic than those who present the round back. The hands and feet are either short or medium in length and are firmly constructed. The thoracic cage is short and broad. The visceral organs vary considerably, both in position and in shape, from those of patients with the round type of back.

Kinesiology

In dealing with postural disturbances of the spine, a thorough understanding of the muscles whose actions play a part in the motion of the lumbosacral spine is essential. Figure 2 demonstrates schematically these muscles. A contraction of the sacrospinalis group, when a person is in the erect or in the extended position, results in an extension of the lumbosacral spine, causing a compressive force to be exerted on the postérior margins of the intervertebral discs at this site. The anterior abdominal muscles are antagonistic in their action, in that they lift the front of the pelvis and thereby reduce the extension of the lumbosacral spine, thus shifting the stress from the posterior to the anterior margins of the intervertebral discs. The gluteus maximus, taking its origin from the posterior portion of the ilium and inserting into the lateral aspect of the upper end of the femur, when in contraction, tends to draw the pelvis down from behind and to force it up in front, the axis of rotation being the hip joint. The action of the glutei, therefore, aids that of the anterior abdominal muscles in reducing the extension of the lumbosacral spine. The hamstring muscles take their origins from the ischial tuberosities which are behind the axis of rotation of the pelvis. A contraction of this group aids the gluteus maximus in drawing the posterior half of the pelvis down and in lifting up its anterior portion. With the exception of

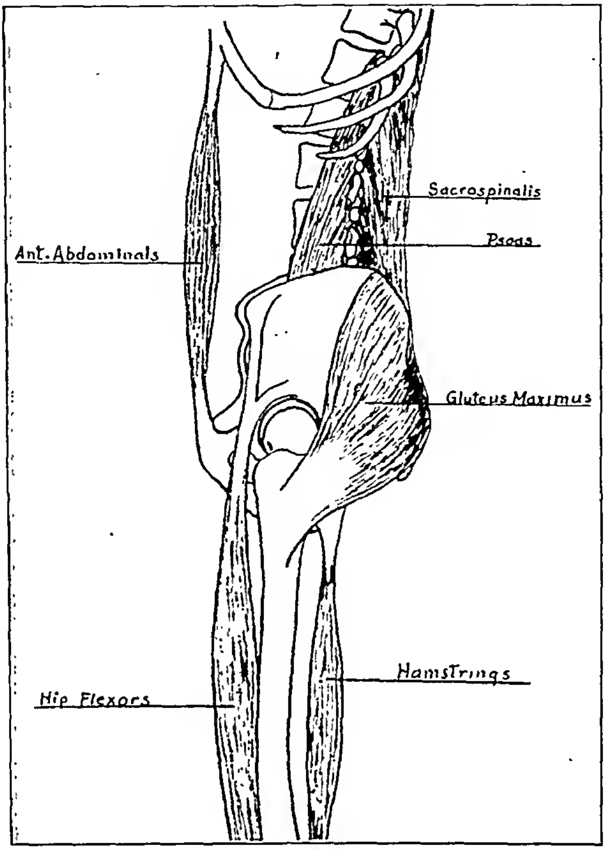

Fig. 2

Schematic drawing, showing principal muscle groups which affect the posture of the lower spine.

the iliopsoas, the hip flexors take their origin from the anterior half of the ilium. A contraction of these muscles tends to draw the anterior half of the pelvis down and to force the posterior half of the pelvis up, thereby aiding the sacrospinalis group in extending the lumbosacral spine. The psoas muscles take their origin from the transverse processes and the posterior halves of the lumbar vertebrae,—behind the vertical axis of the vertebral bodies. When a person is in an erect or extended position, a contraction of these muscles causes an extension of the lumbosacral spine, thereby aiding the sacrospinalis and the hip-flexor groups. This is not true when the hips have been flexed to an angle of 45 degrees or more. In such a position, their point of insertion has been shifted forward and their action is either that of vertical compression or of anterior flexion of the lumbosacral spine.

It becomes evident from a study of muscle action that extension of the spine is brought about and maintained by the sacrospinalis, by the hip flexors, and, when the body is in the erect position, by the psoas. Since faulty posture is a deformity of the erect position, the psoas muscles must be considered an offending group. It is also evident that the principal muscles whose actions are antagonistic to these are the anterior abdominal, the gluteus maximus, and the hamstring groups.

When an infant progresses from the position of all fours to that of biped ambulation the tendency is for the child to fall forward. In assuming such a posture, there is undoubtedly a passive stretching force exerted in the anterior abdominal and hip-flexor groups of muscles. As the sacrospinalis muscles become stronger, the child gradually gains his

balance and the anterior abdominals are stretched out to accommodate the newly assumed position. This stretching compensation is undoubtedly aided by the fact that these muscles are used but little in the erect position. It is different with the hip flexors. They, too, are subject to a stretching force, but their action in the biped gait is as important as the action of the sacrospinalis muscles. Therefore, due to constant use, they do not undergo a disuse atrophy, and they do not respond to the stretching force applied as do the anterior abdominals. When once the erect posture and the biped gait have been accomplished, the sacrospinalis and the hip flexors are constantly in action. This results in an overdevelopment of these two groups of muscles at the expense of the anterior abdominal, the gluteus maximus, and the hamstring groups. When symptoms appear as a result of the hyperextended position of the lumbosacral spine, it is evident that any conservative or surgical measure which interferes with the action of either one of these two muscle groups will at least afford a partial relief. This is due to the fact that the constant extensive force, which is narrowing the posterior width of the intervertebral discs and gradually subluxating the joints formed by the articular facets, has been released.

The author believes that this explains the relief from symptoms which Ober has obtained in severing the iliotibial band. It is very probable that a Soutter fasciotomy would accomplish the same result. It is also probable that it explains the relief from symptoms obtained by Heyman by stripping the posterior superior iliac spine inferiorly and medially. In individuals who have had a normal adolescent growth similar results can be obtained by passively stretching these two groups and actively developing their antagonistic muscles.

History

The history obtained from patients suffering with symptoms due to chronic traumatic destruction of the lumbosacral and lower lumbar intervertebral discs differs from that in which symptoms are caused by the acute traumatic lesion principally in the age period of onset and severity of symptoms. The thinning of the discs due to postural degeneration usually causes symptoms at some time between the ages of thirty and forty. Occasionally, in those patients who present a relaxed attitude and poor muscle tonus, a history of fatigue and pain, aching in character, coming on near the close of day or after a long automobile journey, is obtained as early as the latter half of the second decade of life. However, the symptoms characteristic of degenerative disc changes do not make their appearance until a later period in life.

The usual history obtained is that near the age of thirty-five, without apparent cause, a chronic pain developed in the lower part of the back. On several occasions, usually following some physical exertion in the form of lifting or stooping, severe attacks of pain occurred which required from several days to weeks to obtain relief from symptoms. Eventually the

pain became chronic and moderately severe in character and radiated into one or both hips down the posterior aspect of the thigh and into the lateral aspect of the calf and the ankle.

It is not uncommon to obtain a history from women suffering from this lesion that symptoms were aggravated severely during pregnancy, and in many cases they are inclined to date the onset of symptoms from pregnancy. This can be explained on the basis that the lordosis is increased severely during such times, particularly in women who naturally present an exaggerated lumbar curve. The writer does not believe that an enlarged uterus can exert pressure on the sciatic nerves.

In late neglected cases it is not uncommon to obtain a history of pain in the anterior thigh (femoral-nerve distribution) in addition to the history which has been mentioned.

Regardless of whether the abnormal stress on the disc which has brought about its early degeneration is due to a pelvic tilt or to an exaggerated lordosis, the history usually reveals that symptoms began in the latter part of the third or of the fourth decade of life.

These patients, like those suffering with the acute lesion, frequently give a history of sleeping on the side, with one or both knees drawn up, or on the face with a pillow under the abdomen. They are unable to work in a stooped position and often complain of pain when bending over a wash bowl or working over a kitchen table, as well as in lifting objects. Long automobile rides usually cause severe discomfort. These patients frequently complain of an aggravation of symptoms following prolonged standing.

Symptomatology

Examination of patients suffering with this lesion reveals that about 15 per cent. present a pelvic obliquity which is frequently due to a short leg. When the patient is viewed from behind, this can be readily observed in that the spine presents a postural scoliosis, the pelvis is tilted, one lateral gluteal fold is lower than the other, and the vertical fold forms an angle with the perpendicular. These patients may or may not present an exaggerated lumbosacral lordosis.

The patients who do not present a pelvic obliquity show an exaggeration of the lumbosacral lordosis. Their posture may be of the round hollow, round, or hollow types. The majority of patients present one of the first two types; the latter type is less common in its occurrence. A protrusion of the abdomen is usually seen and, when symptoms are acute, a mild spinal list of the sciatic type is not uncommon. Lumbosacral and sciatic-notch tenderness on one side or on both sides is usually a prominent subjective symptom. If the symptoms are acute at the time of the examination, tenderness of the entire superior gluteal region on one side or on both sides is found. In the patient presenting a round hollow back, anterior flexion of the lumbosacral spine is limited and manifested in the patient's inability to bend forward and to touch the toes with the knees

extended. Other spinal motions may or may not be limited, depending on the severity of symptoms at the time of the examination. Extension of the spine is usually painful, as is also lateral flexion to the affected side when symptoms are unilateral. Extension of the hips is frequently limited, due to short hip flexors. This is best demonstrated by the Thomas test with the patient's knees over the edge of the table and bent at right angles. Patients with short hip flexors also present taut iliotibial bands, as determined by the test recently described by Ober.

In those cases which present a fixed exaggerated lumbosacral lordosis, the straight-leg-raising test—extension of the knee with the hip flexed—will show evidence of hamstring limitation. This should not be interpreted as hamstring shortening. It is due to the fact that the posterior rotation of the pelvis has elevated the ischial tuberosity and increased the distance between the origin and insertion of the hamstring group. This fact can be readily demonstrated by making this test on a person who has the ability to roll the pelvis both forward and backward.

In cases of long standing, in addition to the findings mentioned, the segmental character of the disease may become evident, in that a hyperalgesia may be found over the sensory distribution of one fifth lumbar nerve or of both nerves. On two occasions, in addition to a sensory change in the fifth lumbar nerve, the author has found a hyperalgesia over the sensory distribution of the fourth lumbar nerve. In both instances, the roentgenograms revealed a marked settling, involving the third, fourth, and fifth lumbar intervertebral discs. The Achilles-tendon reflex is frequently sluggish in reaction and occasionally is absent.

Pathology

The pathology is practically the same as that found in patients suffering from the acute traumatic lesion,—that is, degenerative changes involving the annulus fibrosus and the nucleus pulposus. There is a subluxation of the facet articulations which results in degenerative arthritic changes. These patients more often present such findings in the lower lumbar articulations, as well as at the lumbosacral articulation, than do those suffering from the acute traumatic lesion. The neural pathology is undoubtedly the same; however, since symptoms are rarely as severe in this group, the opportunity of viewing it at operation is less frequent.

Roentgenographic Findings

The roentgenographic studies of those patients presenting a pelvic obliquity show a tilt of the sacral table, a narrowing of the lumbosacral joint space, a subluxation of the lumbosacral facets, and frequently hypertrophic lipping and sclerosis involving the facet articulations and, occasionally, the vertebral bodies. The roentgenographic studies of those cases which are due to a lumbosacral lordosis show a narrowing of the posterior margin of the lumbosacral joint space. A similar narrowing of the posterior portion of the intervertebral joint spaces continues through-

out the lumbar region. The subluxation of the facets, as well as the hypertrophic lipping and sclerosis, is most marked at the lumbosacral articulation and becomes less apparent as they approach the lumbothoracic spine.

Treatment

The treatment of patients suffering with chronic traumatic changes, due to a disturbance in postural mechanics, varies according to the age of the patient and the severity of the symptoms.

The patient who presents a pelvic obliquity should be compensated by adding a lift to the heel of the shoe. In addition to this, it is usually necessary to establish treatment along the same mechanical and reconstructive lines as is indicated in the patient suffering from a postural disturbance, due to an increased lumbosacral lordosis. For this reason, after the pelvic obliquity has been compensated, the patient is treated as any other postural case.

Men under the age of fifty and women under the age of forty who present an exaggerated lordosis of the lumbosacral spine, whose roentgenograms reveal narrowing of the posterior margins of the lower lumbar and lumbosacral intervertebral discs, and whose symptoms are not acute but low-grade and chronic in character are treated by postural exercises and instructions in positions. In addition, all evident foci of infection should be removed and high heels should be replaced by medium or low heels. In many cases it is necessary to make the change from high heels gradually, in order to avoid a severe acute foot strain. This is most liable to occur in the gouty type of individual who presents a round hollow postural deformity of the spine.

A patient of this type with an acute attack is treated in a plaster jacket. The cast is applied to the patient in the standing position with the spine flexed to such an extent that the lordosis of the lumbosacral region is eradicated. The jacket extends from the angle of the scapula to the midsacral region and is trimmed in front to permit right-angle flexion of the hips. The patient is then put to bed with the knees and the hips flexed for a period of from five to fifteen days, depending on the relief from symptoms. He then becomes ambulatory in the cast for a period of from three to five days, after which the cast is removed and an orthopaedic corset is substituted. As soon as all symptoms have disappeared, postural exercises are instituted and the use of the garment is discontinued. The patient is also instructed in positions and, if female, is advised to spend most of her time in shoes with a low or a medium heel.

In patients past the ages mentioned, unless they are unusually well preserved, the treatment differs in the following respects.

1. Postural exercises are instituted in order to restore muscle tone, but they are not carried out as strenuously as in the younger individual, due to the fact that a voluntary change in posture at this age period is a remote possibility.

2. Some form of fixation is necessary, in order to limit motion in the facets of the lumbosacral and lower lumbar articulations. In milder cases, an orthopaedic corset, extending from about the tenth thoracic vertebra down to the lateral gluteal folds, preferably with a pelvic band incorporated, will be sufficient. *In more severe cases*, it is necessary to support the lower spine with a brace which will eradicate the lordosis and which will at the same time afford immobilization. This brace is the same as that already referred to and will be described later.

The treatment of patients in this group who suffer an acute attack differs from that of the younger age group in that the garment or brace which is applied following the removal of the cast is worn either as a permanent form of fixation or for a period of time long enough to accomplish a natural fixation of the low spine. The postural exercises are instituted in this group to obtain muscle balance and not to bring about a voluntary postural correction.

Resistant cases which fail to respond to the most radical form of conservative treatment—the wearing of a flexion cast for a period of fifteen days or longer, followed by a corrective brace and postural exercises for a period of several months—should be treated surgically unless physical, mental, or economic conditions contra-indicate such treatment. Provided that symptoms are segmental in character, facetectomies, in addition to the fusion, should be done.

Postural Exercises

The success in changing a patient's posture through voluntary effort on his part depends to a large extent upon his understanding of the mechanical principles involved. For this reason, as a rule less effort is required in instructing a male patient. The physiotherapist should follow without variation the instructions of the clinician in every case. Patients should be warned against setting-up exercises as given through radio programs and popular magazines, due to the fact that such programs usually result in an active development of the spinal muscles which in our sedentary type of living are already overdeveloped as compared to their opposing groups.

It becomes evident from the principles already stated that a correct postural program should include: (1) an active development of the anterior abdominal, the gluteus maximus, and the hamstring groups; and (2) a passive stretching of the sacrospinalis and hip-flexor groups. Any exercise which calls into action the psoas or sacrospinalis muscles is liable to prolong, if not to increase, symptoms.

The indication for passive stretching of the hip-flexor or sacrospinalis muscles should be determined before the postural program is instituted.

Fixed posterior rotation of the pelvis and shortening of the spinal muscles can be determined by having the patient, with knees extended, bend forward and attempt to touch the toes. The same determination can be made by having the patient lie on his back with the hips flexed; the

operator then attempts to force the knees down to the axillae. Normally the pelvis will rotate forward, lifting the sacrum off the table, and the knees will contact the anterior axillary folds. In cases where there is a fixed posterior rotation of the pelvis this cannot be accomplished.

Shortening of the hip flexors can be determined by having the patient lie on his back on the table in such a position that the knees will be flexed to 90 degrees over the edge of the table. The hips are then flexed until the knees approximate the anterior axillary folds. The patient is then instructed to grasp tightly with both arms one knee and to extend completely the other hip. If the hip flexors are not shortened, the extended

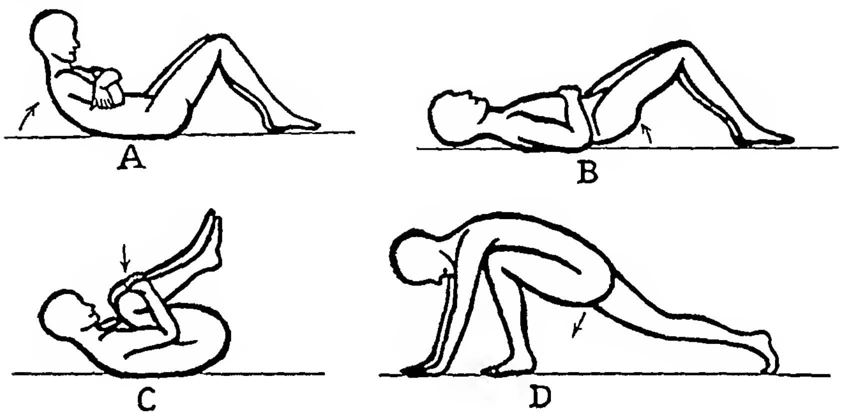

FIG. 3

Postural exercises designed to reduce the lumbosacral angle: *A*, active development of the abdominal muscles; *B*, active development of the gluteal and hamstring muscles; *C*, passive stretching of the sacrospinalis; *D*, passive stretching of the hip flexors.

thigh will contact the table without release of the hold on the opposite knee. This procedure is but a slight exaggeration of the Thomas test for flexion deformities of the hips.

Thin individuals who present the round postural type of back and hyperextended hips do not respond well to a postural program. Passive stretching of muscles is rarely indicated in this group. However, forced flexion of the lumbosacral spine should be done in those cases which show a fixed posterior rotation of the pelvis, due to pathological changes at the lumbosacral articulation.

The postural exercises which the author has used for the past two years with considerable satisfaction are shown in Figure 3.

Figure 3, *A* represents the exercise employed in developing the anterior abdominal muscles. The knees should be drawn up in order that the psoas muscles may not be called into action. The exercise in which the patient lies flat on his back and flexes the hips with the knees extended should not be given for developing abdominal muscles, due to the fact that the psoas action frequently aggravates symptoms.

Figure 3, *B* represents the exercise employed in developing the glu-

teus maximus and hamstring muscles. The pelvis is rotated forward by contracting these two muscle groups. The lumbar spine should remain on the table and the flexion should be accomplished at the lumbosacral articulation. The idea is best conveyed to the patient by telling him to "squeeze the cheeks of his buttocks together". The same exercise can be taken in a sitting position in an uncushioned chair. The buttocks should be slid forward to the front half of the seat and the pelvis rotated forward by contracting the gluteal and hamstring muscles.

Figure 3, *C* represents a passive exercise used in stretching the spinal muscles and in freeing the posterior fixation of the lumbosacral articulation. The patient grasps his knees, one in each hand, and draws them tightly to the axillae, attempting to lift the sacrum off the table.

Figure 3, *D* represents the passive exercise generally used in stretching the hip flexors. The same exercise can be taken in different ways, but that represented in the illustration has been found to be most effective. One hip is flexed until the knee contacts the chest at the anterior axillary fold. This attitude rolls the pelvis forward, reduces the lumbosacral angle, and avoids stretching of the abdominal muscles. The weight of the upper trunk is supported by the extended arms. The knee of the extended lower extremity is held rigidly in extension and weight is taken on the extended toes. Such a position exerts a pull principally on the hip flexors. By forcing the buttocks toward the heel of the foot of the flexed extremity, the stretching force exerted on the opposite hip flexors can be increased to any desired degree. Both groups of hip flexors can be affected by alternating the positions of the lower extremities.

This series of four exercises accomplishes an active development of the abdominal, gluteus maximus, and hamstring muscles, as well as a passive stretching of the hip flexors and sacrospinalis muscles.

The exercises outlined will accomplish a proper balance between the flexor and the extensor groups of postural muscles, but it is extremely important that the patient should understand the mechanics of the posture desired. Certain expressions such as "sit up straight", "throw your chest out", and "draw in your abdomen", should be stricken from our postural programs. The first statement results in protrusion of the abdomen and arching of the lumbar spine. The second causes the patient to force his shoulders back and to increase the lordosis, while the last results in his drawing up the diaphragm and holding his breath, which has nothing to do with posture.

The patient should be instructed to stand tall with the vertex (never the frontal region) of the head nearest the ceiling. The shoulders should be permitted to hang comfortably forward. The pubic region should be continuously lifted, and arching of the back should be avoided at all times. Posture should be checked against a vertical surface. With the patient's heels and calves against the wall, the lumbar spine should approximate the wall so closely that the hand cannot be passed between them. If it is

necessary to flex the knees to assume this position, further stretching of the hip flexors is indicated.

When the patient stoops or lifts, the pelvis should first be rotated forward and the floor then approached by flexing the hips and knees. The patient should never bend or lift with the knees extended. The load should be lifted by extending the hips and knees rather than the lumbar spine.

The sitting position should not be an attitude with the shoulders thrown back and the lumbar spine arched, but, rather, the lumbar lordosis should be eradicated and the entire spine should be a mild total curve with the concavity forward. This means that the patient should sit in a slightly slumped position and, when possible, the knees should be higher than the hips,—this is particularly true when riding in an automobile. A slumped position—that is, with the buttocks pushed slightly forward, the lumbar spine rounded, and the feet on a footstool—will usually permit a patient who otherwise might suffer severely to ride indefinitely without appreciable discomfort. If it is necessary to drive, the driving range should be shortened as much as possible, so that the knees are higher than the hips. In such a position, any jar is taken on the back of the sacrum and its force results in a widening of the lumbosacral foramina. On the other hand, if the force is taken in the erect attitude, it results in a constriction of the lumbosacral foramina.

Strenuous competitive athletics should be avoided by those who have a destruction of the lumbosacral intervertebral disc, for it is impossible under such circumstances to guard the positions of the low spine. Swimming is permissible, but diving should be avoided. Horseback riding by those who are sufficiently trained to take the jar on the extremities and to keep the abdominal muscles contracted is permissible. Ice skating frequently will relieve an attack of low-back pain; however, those untrained in the art may fall and thereby severely increase the symptoms. The carrying of a pack on the back is an excellent exercise for those suffering with this lesion, but the lifting and carrying of loads in front of the body should be avoided as much as possible for reasons which have already been given.

Patients suffering with this lesion should sleep with the knees and the hips flexed. This can only be accomplished on the back or on the side. They should be warned against sleeping on the abdomen as such a position increases the lordosis and aggravates the symptoms. In severe cases it is desirable to place a modern hospital bed in the home in order that such a sleeping position can be readily obtained. In other cases a roll placed under the mattress at the level of the knees will suffice. If the patient turns to his side during the night he will unconsciously draw his knees above the elevation and thereby maintain a satisfactory position.

It will be noted that the principles herein outlined are directed toward the restoration of those muscles which are sacrificed by the erect posture, and the restoration of the contour of the lower spine to resemble

as nearly as possible that of the quadruped animal. There are those who will object on the grounds that such principles are productive of round shoulders; however, it has been the author's experience that round shoulders are compensatory for an exaggerated lumbosacral lordosis. It will be a fortunate day for the "low-back" sufferer when school seats, stenographers' chairs, and chairs of all types are so designed as to discourage rather than to encourage a lordosis of the spine.

Lordosis Brace

The lordosis brace which the writer has used with satisfaction in these cases is so designed as to exert a constant corrective force. It permits free anterior flexion, but prevents extension and lateral flexion of the lumbosacral spine. There are three principal points of pressure,—the thoracic spine, the sacral spine, and the lower abdomen. The brace shown in Figure 4 is to a considerable extent self-explanatory. The

FIG. 4
Lordosis brace. Three-point-pressure principle.

dorsal and sacral bands are made of thin flexible steel covered with leather. The uprights attached to the sacral band hinge at *B*. The upper strap, which buckles to the abdominal pad, is only a stabilizing strap for the dorsal band and should not be drawn too tight. The lower strap, which is attached to the lower end of the upright *ABC*, furnishes the corrective pull. This strap passes through a ring attached to the sacral band, then forward under upright *ABC*, and fastens by a buckle to the abdominal pad. The abdominal support which lies under the abdominal pad is made of perforated pure rubber known as "acid packing". It fastens in the midabdominal line by means of snaps similar to those used on the wrists of leather gloves.

CONCLUSIONS

In concluding this phase of the discussion of lesions of the lumbosacral spine, which deals only with destruction of the intervertebral disc, the author wishes to add that lumbosacral fusion is not a panacea for all

low-back troubles. In his experience it has afforded relief from symptoms in those patients who suffered only from a traumatic destruction of the lumbosacral intervertebral disc, and who had not experienced segmental symptoms. Lumbosacral fusion, combined with facetectomy, has given relief to those who suffered only from a traumatic destruction of the lumbosacral disc and who had experienced segmental symptoms.

Surgery should never be employed until a thorough conservative program has overcome a fixed lumbosacral lordosis and lengthened the short hip-flexor muscles. If this is not accomplished preoperatively, the patient will be liable to develop symptoms just above the graft a few months after becoming ambulatory. It has been the writer's experience that a well-planned conservative program will eliminate the need for surgery in most cases.

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SACRO-ILIAC FUSION

BY F. A. BLOOM, M.D., HOUSTON, TEXAS

The purpose of this paper is to present a new method for fusion of the sacro-iliac joint. The method which the author has devised differs from the classical Smith-Petersen operation in the approach and in the manner in which the plug is removed from the ilium. As far as the writer has been able to find out, from a search of the literature, this particular procedure is new.

The operation begins with the usual preparation of the skin prior to any orthopaedic procedure. The patient is draped in the prone position. The anaesthetic may be either spinal or general. A line is drawn on the skin from the anterior superior spine to the posterior superior spine of the ilium. At a point on this line, one and one-half inches anterior to the posterior superior spine, a perpendicular is dropped downward for half an inch.

An incision, three to four inches in length, is then made in the direction of the fibers of the gluteus maximus, the center of the incision coinciding with the lower end of the perpendicular line. The incision extends down through the skin and fascia to the muscle. The palpating finger then splits the muscle fibers and is carried down until the superior border of the greater sciatic notch is defined. With the finger as a guide, a Steinmann pin, three-sixteenths of an inch in diameter and eight inches long, is then passed down through the muscle fibers to a point on the ilium, one inch superior to the upper border of the greater sciatic notch. It will be found that this point will coincide with the center of the incision.

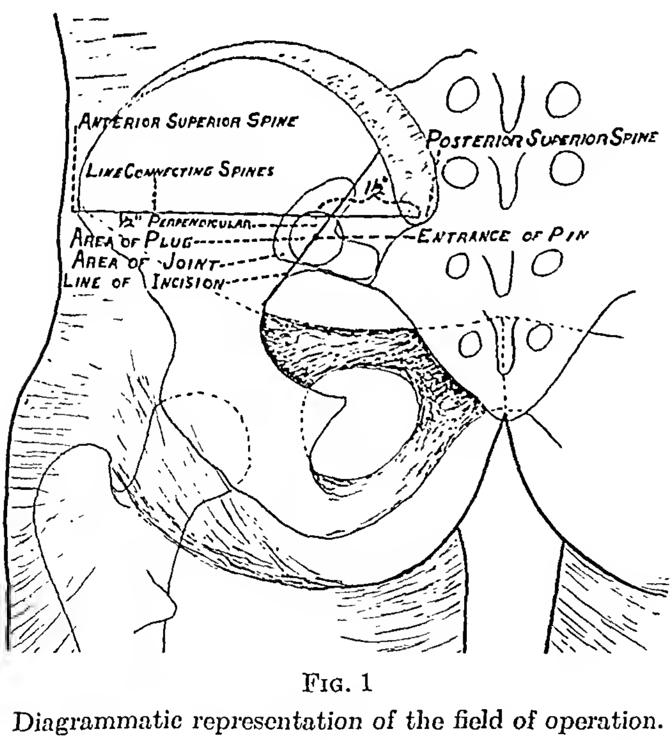

Fig. 1

Diagrammatic representation of the field of operation.

The pin is then driven into the outer table of the ilium perpendicular to the surface through which it passes. By driving the pin slowly with a small hammer, an increase in density can be detected when the pin strikes the joint. The pin is driven approximately one-half an inch after it passes through

the joint line. Blunt dissection will enable the operator to expose a small area of the ilium at the base of the pin. Two retractors with blades, four inches long and two inches wide, are inserted above and below the pin. These easily expose the area of bone at the point of entrance of the pin into the ilium. A hole saw, one and one-quarter inches in diameter, attached to a fenestrated shaft, is passed over the pin down to the ilium. A standard Hudson surgical brace is then fitted to the shaft of the saw and a circular piece of bone is cut. If the cutting is done slowly, it is easy to determine when the saw passes through the joint line. The cutting is continued until the saw is a quarter of an inch into the sacrum,—that is, through the joint line for a quarter of an inch. After this has been done, the saw and the pin are removed.

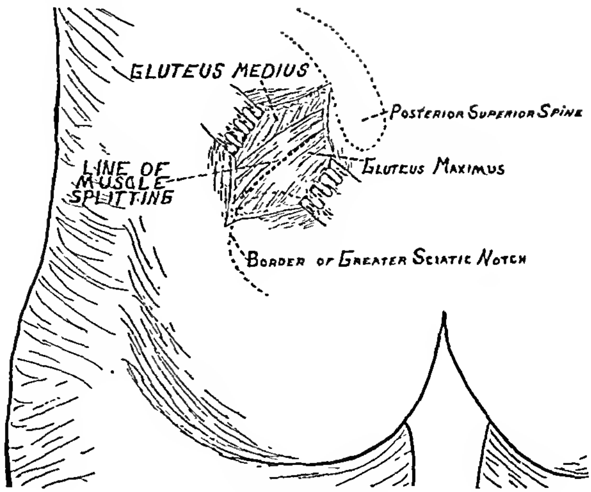

FIG. 2

Skin and superficial tissue retracted, showing the muscle fibers and the line of the muscle splitting.

Usually the plug of bone will be loosened sufficiently to come out with the saw. If not, the plug can be easily loosened with a periosteal elevator, or with a large gouge, by a simple prying motion through the cut. At times the plug may include both the iliac and the sacral portions of the joint. On the other hand, it may include only the iliac portion. If the sacral portion is not loosened, it is necessary to remove the cartilage from this piece by means of a large curette or gouge, taking care that all of the sacral cartilage and cortical bone are removed. If both portions of the joint

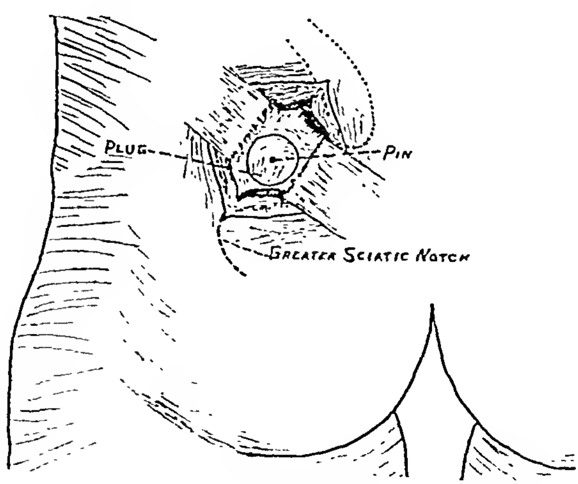

FIG. 3

Muscle retracted, exposing the lateral aspect of the ilium. The point of insertion for the pin and the area of the plug are indicated.

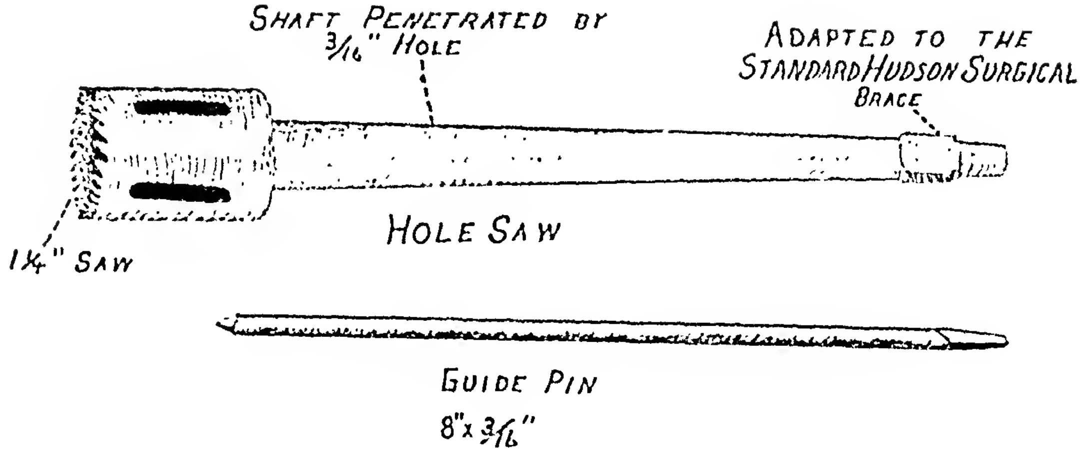

FIG. 4

Drawing of the hole saw used for cutting the plug. The saw is one and one-quarter inches in diameter. The shaft is pierced throughout its length by a hole, three-sixteenths of an inch in diameter. The small end of the instrument is shaped to fit a standard Hudson surgical brace.

come out as a plug, these two pieces are separated through the joint line and the cartilage is removed from each. The denuded plug is then replaced in the hole and wedged tightly by means of a slight impaction. The wound is closed in the usual manner. Both joints can be fused by the method described in from fifteen to twenty-five minutes, including closure of the skin, without any undue haste.

No immobilization of any kind is applied. The sacro-iliac joint has been approached in such a manner that none of its supporting structures have been weakened and the author sees no more reason for support following the operation than before the operation was performed. Since the plug is impacted through the joint line, it forms a graft, about one and

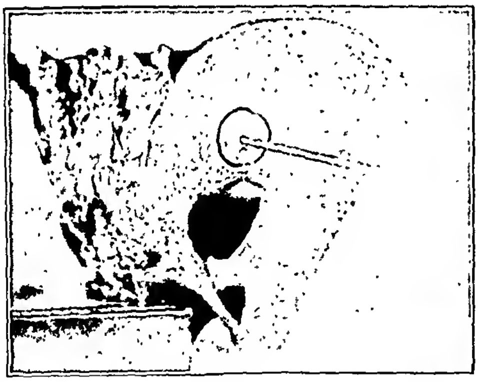

FIG. 5

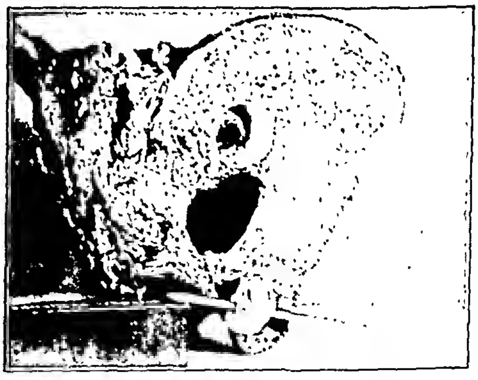

FIG. 6

FIG. 5:

A Steinmann pin, three-sixteenths of an inch in diameter and eight inches in length, is seen driven through the sacro-iliac joint of a mounted pelvis. The plug has been cut with the hole saw. The relationship of the plug to the greater sciatic notch is well demonstrated.

FIG. 6:

The cut plug of the ilium has been removed and remains transfixed by the pin. The cartilage of the sacral side of the sacro-iliac joint can be seen within the hole in the ilium.

one-quarter inches in diameter, across the joint, and bony union takes place rapidly.

Following this operation, the patients have little or no surgical shock. They usually feel quite well on the next day and need no opiates or other pain-relieving drugs. The patients are permitted to sit up as soon as they desire,—usually in from three to four days. Unless other factors contra-indicate, the patients are allowed out of bed without restriction in fourteen days.

The operative procedure described has been carried out on four patients. The following are summaries of these cases.

CASE 1. H. C., negro, male, thirty-eight years old, a laborer, had had constant pain in the back for eighteen months.

Diagnosis: Bilateral chronic hypertrophic arthritis of the sacro-iliac joints.

Treatment and Follow-Up: On August 22, 1936, both sacro-iliac joints were fused. On September 6, 1936, the patient was discharged from the hospital, walking. Check-up roentgenograms, on October 25, showed bony union about the plug in both joints. Clinical tests for sacro-iliac pain were negative. The patient stated that he was greatly improved, but he did not feel that he was able to return to work. The author has been unable to locate the patient since October 25, 1936.

CASE 2. A. C., white, male, forty-two years old, a laborer, had spondylolisthesis of four years' standing with partial spastic paralysis of the lower extremities.

Diagnosis: Disuse atrophy and relaxation of the sacro-iliac joints.

Treatment and Follow-Up: On September 12, 1936, both sacro-iliac joints were fused. Postoperative recovery was uneventful. On December 14, 1936, check-up roentgenograms showed solid bony union across both sacro-iliac joints. No true sacro-iliac pain could be demonstrated clinically. The patient was greatly improved, but still complained of some pain in the region of the right sacro-iliac joint.

CASE 3. J. D., white, male, fifty-two years old, a laborer, had had pain in the back for the past twenty years. Two years prior to admission to the hospital, the patient had lifted a heavy object and had been unable to work since that time.

Diagnosis: Hypertrophic arthritis and sprain of the right sacro-iliac joint.

Treatment and Follow-Up: On November 4, 1936, both sacro-iliac joints were fused. Postoperative recovery was uneventful. The patient was dismissed from the hospital sixteen days following the operation. On January 20, 1937, roentgenograms showed a firm union at the site of the arthrodesis on the right. Union of the left joint was also present, but not as complete. The patient stated that he was greatly improved. Tests for sacro-iliac pain were still slightly positive on the right. The tenderness on pressure over the right sacro-iliac ligaments had completely disappeared.

CASE 4. W. W., white, female, thirty-eight years old, had had constant pain in the right thigh for three and one-half years.

Diagnosis: Sacralization of the fifth lumbar vertebra on the right. Right sciatic neuralgia.

Treatment and Follow-Up: On November 28, 1936, the lumbosacral joint was fused by a graft from the ilium. Both sacro-iliac joints were fused, and the sacralized process was excised. The patient was then placed in a plaster jacket. This patient was immediately and completely relieved of the sciatic pain, probably due to the removal of the sacralized process. On February 17, 1937, the jacket was removed and the patient was allowed to get out of bed wearing a back brace. Roentgenograms showed good union across both sacro-iliac joints.

In all of the cases cited, there was both clinical and roentgenographic evidence of bony union of the sacro-iliac joint in three months following

the operation, and in no case was there evidence of non-union. In Case 4, the operation on the sacro-iliac joints was done as an additional stabilizing procedure in a congenitally malformed back, with the hope that future trouble might be avoided.

ADVANTAGES

1. Fusion of the sacro-iliac joint is done through a small incision and with less dissection than in other methods.
2. The time consumed in completing the operation is diminished.
3. The bone plug is removed accurately from a predetermined site which is fixed by the pin from the outside, before extensive dissection obscures the field.

DISADVANTAGES

The operation has been done upon two joints of a mounted pelvis, six joints in cadavera, and eight joints in living patients. The author has as yet found no disadvantage. The possibility of driving the pin too far has been considered; however, a rather wide range of safety is left after the pin passes through the joint. The pin must pass about one and one-half inches past the joint line before any real damage can be done. This can be avoided by using a moderate amount of care in inserting the pin. The possibility of cutting the plug too deep is rather remote, since the hole saw is not of sufficient length to allow this to happen.

CONCLUSIONS

1. A bone plug, one and one-quarter inches in diameter, can be removed through the sacro-iliac joint by the method outlined.
2. Bony fusion of the sacro-iliac joint can be brought about by the procedure described.
3. As performed by the author, the operation for fusing the sacro-iliac joint is made simpler and causes less reaction in the patient than other methods used.

CONSERVATIVE THERAPY FOR FRACTURE OF THE OS CALCIS*

BY OTTO J. HERMANN, M.D., BOSTON, MASSACHUSETTS

The most common variety of fracture of the os calcis is that in which there is a rather formless comminution of the bone as a whole,—the bone is broken through near a vertical plane, just in front of, or commonly through, the posterior articular surface between the astragalus and the os calcis, with a lateral broadening ("piling up") and pushing up of the posterior part of the heel. It is with this type that this paper is concerned.

At the Boston City Hospital, for the past thirty years, we have proceeded along conservative lines of treatment of this fracture, trying out, rejecting, and retaining innovations both in the initial treatment and in the after-care. For example, in the early 1920's we used continued traction with tongs, and later, in 1928, continued Kirschner-wire traction. We discarded these innovations when, despite careful initial technique, asepsis and follow-up, sepsis developed in almost 10 per cent. of the cases. This we know can be devastating and crippling in such a cancellous bone as the os calcis. This experience inclined us to conclude that foreign-body traction through a traumatized area is surgically unsafe and unsound.

Our most radical and important modifications came in our after-care of these fractures. Here we discovered that our greatest bugbear, the repiling up of bone in the submalleolar areas, was checked by constant snug pressure maintained over a period of from ten to twelve weeks. We gradually worked out our definite routine after-care whereby we checked this excess new callus formation while the foot was in plaster fixation and during the first six weeks following the removal of this plaster cast. We finally adopted the following steps which we now use in our treatment of fractures of the os calcis of the crushed type.

PRELIMINARY TREATMENT

1. Roentgenograms are made upon admission, a lateral and an axial view of both heels being taken. The films of the uninjured heel are used as a comparison for measurements of the injured one and also to detect any bone anomalies that might complicate the interpretation of the fracture. The axial view is made as follows: a strip of two-inch roller bandage is placed in a loop about the anterior arch of the foot with the ends held by the patient; the foot is drawn into moderate dorsiflexion: the film is placed underneath the heel and the lower leg; and, finally, the axis of the x-ray tube is directed onto the plantar surface of the heel at an angle of 45 degrees. In severe cases, a third view is taken in an effort to see more clearly the subastragalar joint. Since compression fractures of

* Presented before the Meeting of the Fracture Committee, American College of Surgeons, Boston, Massachusetts, January 15, 1937.

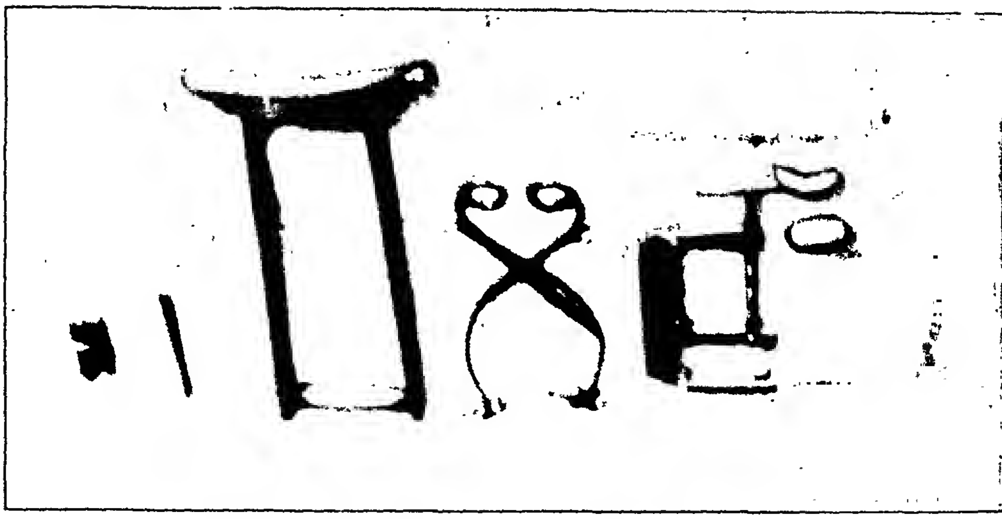

FIG. 1

Operating kit: a rolled sterile towel, a weighted seven-pound wooden mallet, a scalpel, the sawed-off upper end of a crutch, tongs, Forrester clamp, a sterile covered sandbag.

the lower spine occur not infrequently with os-calcis fractures (in about 10 per cent. of our cases) routine lateral and anteroposterior roentgenograms of the lower thoracic and lumbar vertebrae are made to rule out such fractures. This procedure has been adopted by us so that no such lesion will be inadvertently overlooked. There have been patients with fracture of the os calcis, complicated by spine fracture, who did not complain of any back discomfort. Therefore, such a roentgenographic check-up of the spine is now the rule in our first examination. From the roentgenograms of the os calcis the surgeon learns the exact amount of lateral expansion, the comminution present, the condition of the astragalocalcaneal joint, the salient angle or angle of incidence, the location of the vertical and longitudinal fracture lines (one must plot these lines so as to avoid them in the placing of ice tongs during reduction), the condition of the sustentaculum tali, and, finally, the existence or

FIG. 2

Patient turned on side opposite injury. The sandbag is placed under the inner side of the injured heel. A sterile rolled towel is placed beneath the external malleolus. Then, with solid heavy blows, impaction is broken up and the piled-up bone beneath the external malleolus is pounded down.

non-existence of subluxations between the os calcis and the cuboid, or between the astragalus and the scaphoid.

2. The emergency treatment is very simple,—the foot and lower leg are encased comfortably in a "pillow and sides" splint with appropriate bleb dressings and an ice bag if deemed necessary.

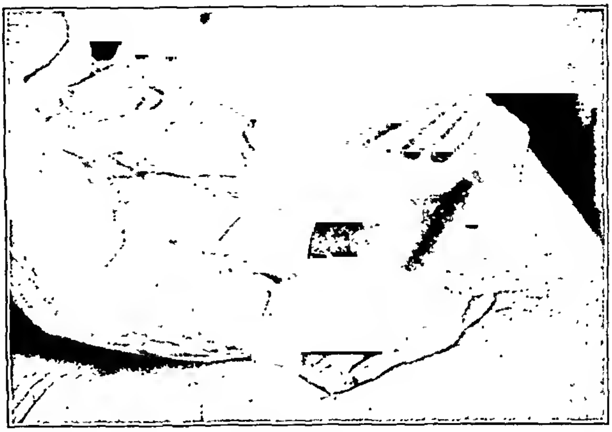

Fig. 3

This illustrates how easily the thumb can be pressed into the depression beneath the external malleolus and the heel can be molded by the fingers after the pounding.

3. A one or two-day "bone prep" is given as soon as the acute local reaction has subsided, which may be from one to ten days.

REDUCTION AND FIXATION

1. The operating kit (Fig. 1) consists of a tightly rolled sterile towel, a sandbag with a sterile cover, a seven-pound large wooden mallet, a pair of bone tongs, the Forrester bone clamp, a sawed-off crutch, a scalpel, a sterile dressing, and two rolled pieces of felt bound by adhesive (four inches by one and one-fourth inches). Besides this kit, there is the usual sheet-wadding and plaster-of-Paris bandages.

2. Local anaesthesia is never used. Generally a light-dosage low spinal anaesthesia, or a gas-ether anaesthesia, is employed.

3. The technique is as follows: The patient is turned on the side opposite the injury and a sandbag is placed under the inner side of the heel. The tightly rolled towel is placed beneath the external malleolus and then,

Fig. 4

With a scalpel, small incisions are made about an inch or so above the apex of the heel. The tongs are driven in and locked, and traction is then made in a rotary fashion, beginning downward and swinging upward, with counter-traction exerted just proximal to the cuboid joint.

FIG. 5

The os calcis is remolded systematically from the external malleolus downward by means of the Forrester clamp. Again traction is exerted downward and upward with counterpressure in the os-calcis and cuboid areas.

with solid heavy blows, the piled-up bone beneath the external malleolus is pounded down until the normal depression beneath the external malleolus is restored. (See Figure 2.) Roughly, we gage it by placing the thumb in this depression and, if the thumbnail is on a level with the outer surface of the external malleolus, we are satisfied. This procedure we have named "disimpaction". Offhand it would seem that such heavy pounding would cause terrific bruising of the tissue, with resulting necrosis. This is not so. In only one case did we get any degree of pressure necrosis and that was in a case in which we did not wait until all the acute local traumatic reaction (swelling, etc.,) had subsided and in which there was insufficient padding. We believe the tightly rolled towel with the broad-faced mallet precludes such damage.

The heel is quickly molded by hand (Fig. 3), and the various motions are tested. The testing of motions, particularly the lateral, is important. It has been pointed out that by doing this we may lose our reduction in part or in whole. If we do not test, we will not know whether there still exists a submalleolar bone block, and whatever is lost at this stage in the reduction is regained immediately by the traction and remolding.

FIG. 6

Small sterile dressings are first placed in the two stab wounds in the heel and then on the dressings is superimposed a snug roll of felt, four by one and one-quarter inches, placed horizontally beneath each malleolus.

With the scalpel, small stab wounds are then made in the upper posterior part of the heel (care being taken that no fracture lines are entered, these having been previously located by x-ray). The tongs are driven in and locked, and with countertraction from the crutch, which has its handle resting against the operator's abdomen

or chest and the cross-bar of the sawed-off end resting against the sole of the foot in the line of the calcaneocuboid and the astragalo-scaphoid joints, lusty traction is made in an arcwise fashion. (See Figure 4.) This pull begins in a downward and outward direction and, with well-sustained traction, it is carried upward and toward the operator. This type of pull was adopted to overcome the posterior vertical pull of the calf muscles through the tendo achillis and the inferior horizontal pull by the intrinsic muscles of the foot. It is here that the value of the preliminary disimpaction is felt,—the large posterior fragment can be pulled down, whereas, if it were left impacted, only a long-continued traction could do this.

Fig. 7

A low plaster-of-Paris cast is finally applied with the foot somewhat inverted and in plantar flexion. While this cast is hardening, pressure is brought to bear over the pads.

The tongs are now removed and the heel is remolded by the use of the Forrester bone clamp (Fig. 5). When the desired compression has been obtained by this clamp, the traction is again applied through the clamp. The entire heel is carefully and systematically molded in this fashion.

The heel is now again examined manually. (At this point we are henceforth to make our check-up roentgenograms, for we have found that check-ups through a plaster cast are quite unsatisfactory.)

Tightly folded sterile dressings are placed over the stab wounds in the heel and held in place by a sterile gauze strip wound about it. A snug roll of felt, four inches by one and one-fourth inches, is now carefully placed at a very slightly oblique angle beneath each malleolus. (See Figure 6.)

A low plaster-of-Paris cast is then applied with the foot in slight inversion and in extreme plantar flexion. While this cast is hardening, manual pressure is applied over the pad areas. (See Figure 7.)

AFTER-CARE

1. The first cast is removed in two weeks. The submalleolar pads are carefully replaced and, with the foot at right angles, a new cast is applied.

2. A new cast and pads are applied every two weeks up to ten or occasionally twelve weeks. We do this so as to maintain constant snug pressure beneath the malleoli, and it gives us a chance to check up on local conditions. (This constant localized pressure has taught us, during the past decade and more, that such pressure surely retards callus formation and, consequently, we have been very careful in the placing of corrective pressure pads or appliances in other types of fractures.)

3. After removal of the last cast, the special ambulatory os-calcis splint (for which the patient has been measured just before application

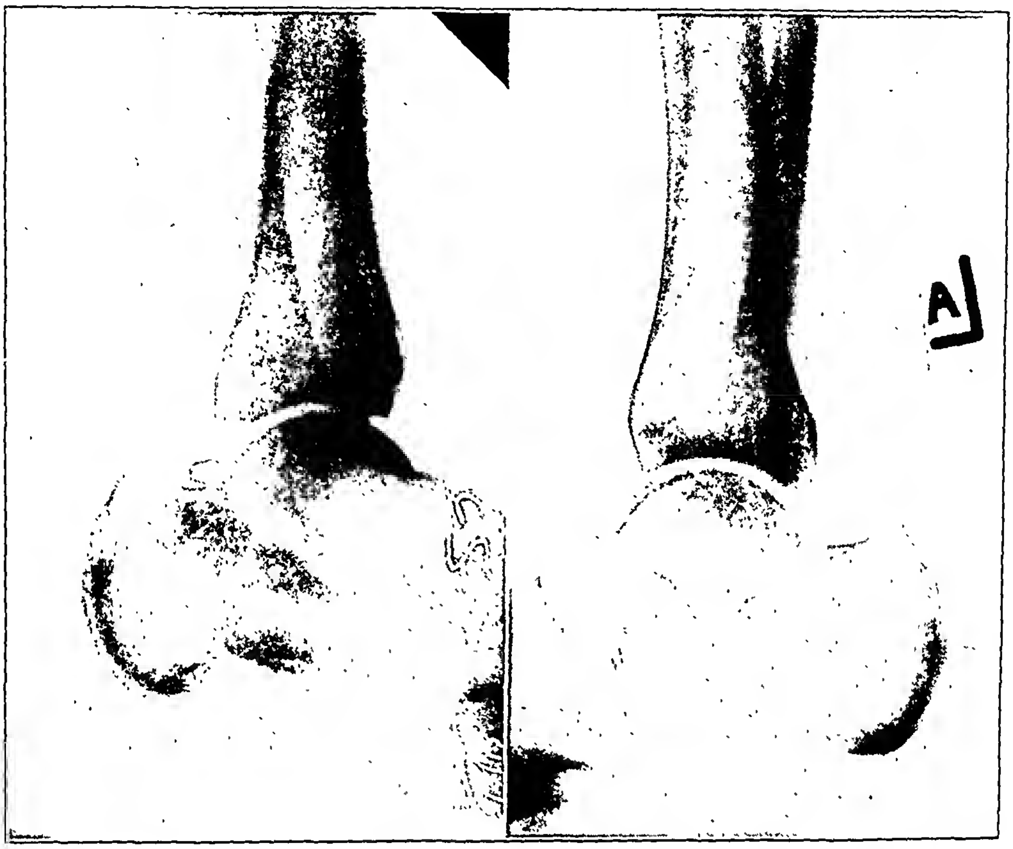

Fig. 8-A

Fig. 8-B

Lateral and axial views, taken on admission.

of this cast) is applied at once. This immediate application of the brace is important, since the pressure pads will be more effective than if applied later when oedema is present.

4. Daily massage, active foot and ankle motions, gradually increasing toe and heel and foot-rocking exercises, supination plank-walking, and radiant heat or hot soaks are also begun after removal of the last cast.

5. Full weight-bearing without crutches, but with an ambulatory splint, is begun ten days or two weeks after omission of the last cast. By that time, the foot, ankle, and leg muscles should have regained their lost tonicity by the daily physiotherapy routine. Greater comfort during the beginning of this weight-bearing period may often be obtained by a one-sixth-inch Thomas heel and a well-fitting inner sole with a pocket for anterior and plantar arch pads.

6. At the end of another six weeks (four and one-half months following initial reduction), the ambulatory splints are gradually discarded, and the patient is instructed as to more strenuous foot exercise and increased walking on rough surfaces. It is during the early part of the direct-weight-bearing period that careful record is made of the patient's pain symptoms. If the patient complains of persistent pain in the affected subastragalar-joint region, and the original fracture was of the intra-articular type and comminuted, then and then only do we consider fusion of the subastragalar joint. In the rare case, where there was originally marked subluxation in the calcaneocuboid or astragaloscaphoid joints, which has not been wholly corrected, and the patient has definite pain there, a triple arthrodesis is considered. Again, where there is definite pain in the tendo achillis, a lengthening of that tendon is considered.

Fig. 9
Postreduction axial views.

Where there is submalleolar-impingement pain, due to a repiling-up beneath the external malleolus, the so-called "scoop" operation is con-

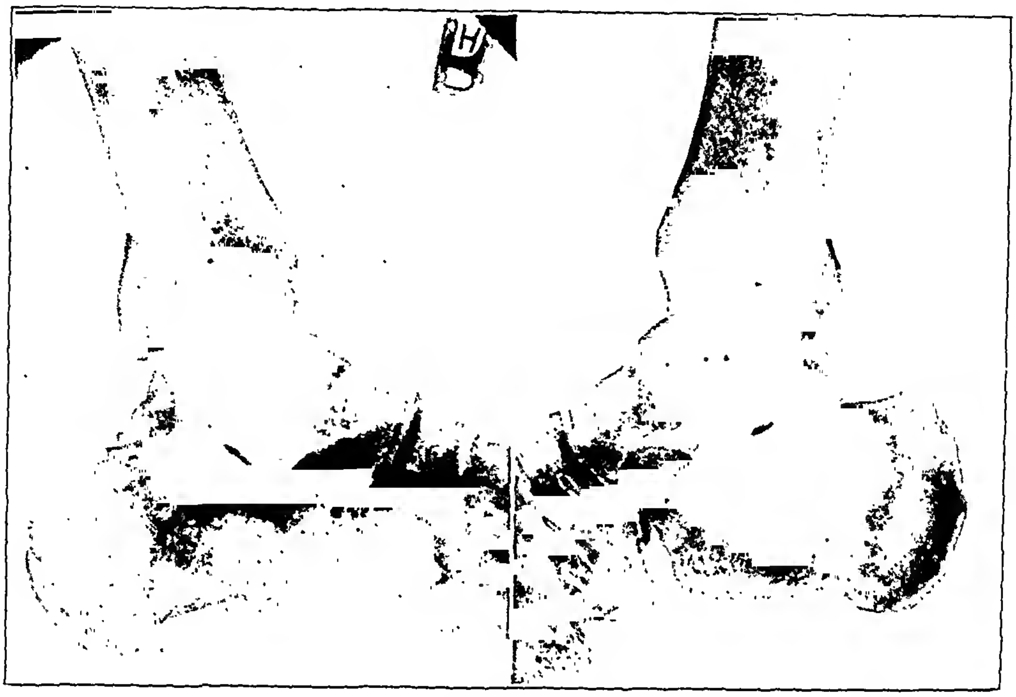

Fig. 10-A

Lateral views taken fifteen months later.

Fig. 10-B

Axial views.

J. J. Roentgenograms showing bilateral fracture of the os calcis. The patient is a painter who dropped fifteen feet from a ladder, striking on both heels. The os calcis was molded and put in fixation and the patient was given the routine treatment. He was back at part-time work in five months and at full-time work in six months. There was absolutely no loss of motion, nor any local complaint of pain, especially in regard to the involved joints.

sidered. Finally, in the very exceptional ease, where the heel has been drawn up markedly and has not been suecessfully pulled and held down, giving a resulting flat (or worse) heel, a "Gleich" operation is considered.

END RESULTS

The results in our latest series of cases were based on an accurate study of the progress of every patient over a period varying from six months to five years. In this series we have taken into account only those to whom we gave both initial treatment and after-care. The total number of such patients was 171 and of these we have excluded the following: twenty-six who did not return to us following the initial reduction, practically all of whom were taken in hand by the various insurance clinics; six not originally treated by us and whom we arthrodesed or "scooped" early; eight who have not yet had four months of treatment. Among the 131 remaining, there were twenty-one with bilateral fractures of the os calcis, which makes a total of 152 acute fractures of the os calcis, of the type mentioned earlier in this paper, that were treated by this method and were under our supervision during convalescence. The end results were classified as: "good", "fair", and "poor". (See Table I.)

TABLE I

END RESULTS IN 152 CASES OF FRACTURE OF THE OS CALCIS

Result	Cases	Per Cent.
Good	111	73
Fair	21	14
Poor	20	13
Total	152	100

The patients in the "good" class are those who, by the sixth or seventh month, had regained full functional use of the injured heel and had no pain or discomfort at any point of the heel after normal activity. That means that there was no submalleolar-impingement pain due to a submalleolar "piling-up", no subastragalar-joint pain, no tendo-achillis discomfort, no plantar or anterior-arch pain, no disturbance in the calcaneocuboid-joint areas, no painful "spur" formations. All such "good" cases need not necessarily have had Grade A anatomical reductions. The "fair" division includes those patients who required seven to eighteen months to return to the normalcy just described.

The "poor" group includes those who, during the first three to four weeks of weight-bearing, had persistent pain in the subastragalar joint, in the calcaneocuboid or astragaloscaphoid-joint areas, about the tendo achillis, or in the submalleolar region. These were the patients upon whom we generally did a subastragalar arthrodesis. (In only one case were we obliged to do a lengthening of the tendo achillis, and in only one case did we do a "Gleich" operation.)

CONCLUSION

The real advance which we have made in our conservative treatment of fracture of the os calcis is in the after-care. We believe our reduction and molding method is quite simple, safe, efficient, non-destructive, and easily mastered. Our routine after-care maintains the initial reduction and molding and prevents the formation of excess callus (especially in the submalleolar region), with its painful and crippling sequelae. It provides the specially placed, constant, snug pressure which we have found essential for a good end result. Finally, we hope that by our work we have demonstrated that routine initial destructive operative procedure should not be adopted in treating fractures of the os calcis. This and other special operations should be reserved for selected cases,—those cases in which the conservative treatment alone is not effective.

The author wishes to acknowledge his indebtedness to Dr. Harold M. Childress for his help in examining the records and in studying the cases which have been considered in the preparation of this paper.

UNUSUAL LOCATIONS OF TUBERCULOUS LESIONS IN THE SPINE

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Since the opening of the Lakeville State Sanatorium for the treatment of surgical tuberculosis in 1910, there have been 470 patients with tubercu-

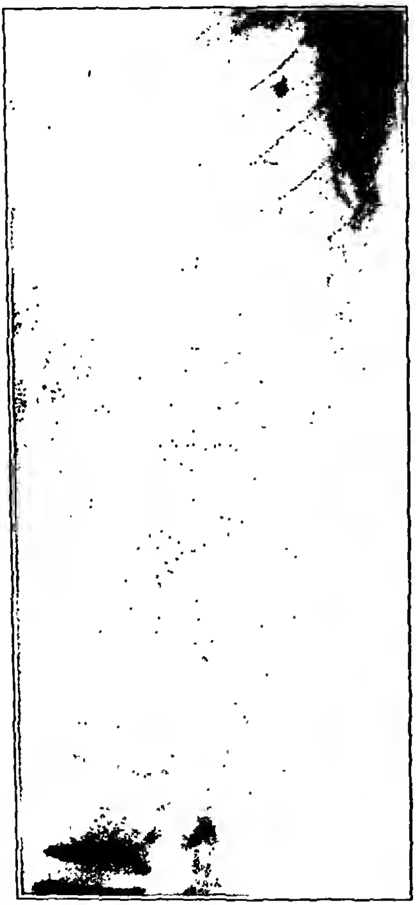

FIG. 1

Roentgenogram of an adult male, twenty-five years of age, with tuberculosis which originated in the intervertebral disc. The disc and the upper and lower plates of the adjacent centra have been destroyed, but the centra have not collapsed. This type occurs in children as well as in adults.

FIG. 2

Tuberculous disease in a girl, aged thirteen. The destructive process originated in an intervertebral disc in the lumbar spine. The roentgenogram also reveals extensive involvement of the thoracic spine with invasion of the disc in the two lower bodies. The other diseased thoracic bodies show the ordinary tuberculous involvement of the centra.

FIG. 3

Roentgenogram of an adult female, aged twenty-six, showing tuberculosis of anterior upper edge of the third lumbar centrum and slight narrowing of the intervertebral disc. Such cases have been thought to be malignant metastases until proved to be tuberculosis by material from an abscess.

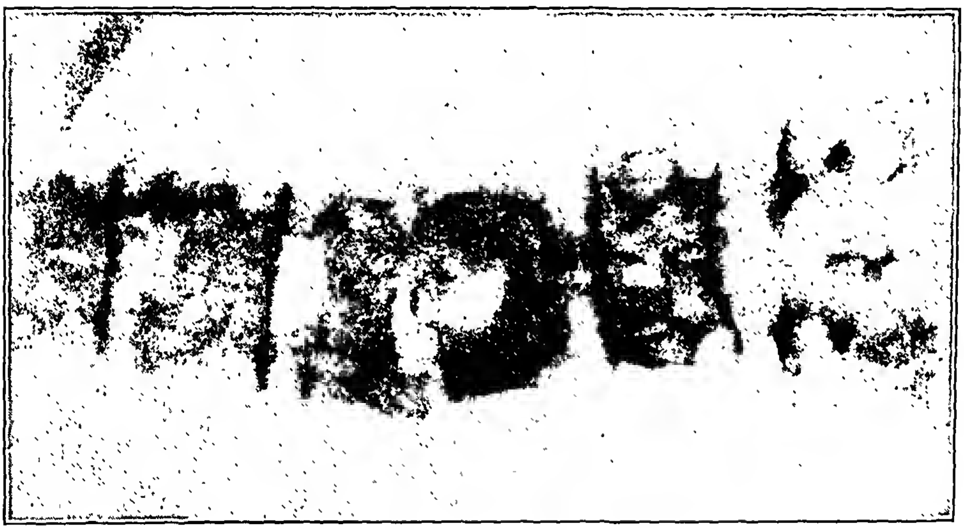

FIG. 4

Roentgenogram of a girl, aged nineteen, showing destruction of the left lateral lower edge of the second lumbar vertebra. The disc is still present but thinned. A bone-graft was used with good results.

FIG. 5

Roentgenogram of an adult male, aged twenty-four, showing tuberculosis of the lower part of the second lumbar body. The disc still persists. The anterior wall of the third lumbar body is being absorbed.

FIG. 6

Adult male, aged fifty-three, with tuberculosis of the fourth and fifth cervical vertebrae. The roentgenogram shows narrowing of the disc and of the anteroposterior diameter of the bodies, no collapse of vertical height, and a retropharyngeal abscess. Tuberculous organisms, as well as bilateral tuberculous epididymitis, were found. The patient was treated for ten years in the Sanatorium with a leather collar.

FIG. 7

Roentgenogram of a girl, sixteen years old, showing destruction of the inferior articular process of the third lumbar vertebra and of the superior articular process of the fourth lumbar vertebra on the right. Bismuth paste, injected into the sinus, filled the abscess and led up to the diseased joint. Tubercle bacilli were found in the discharge.

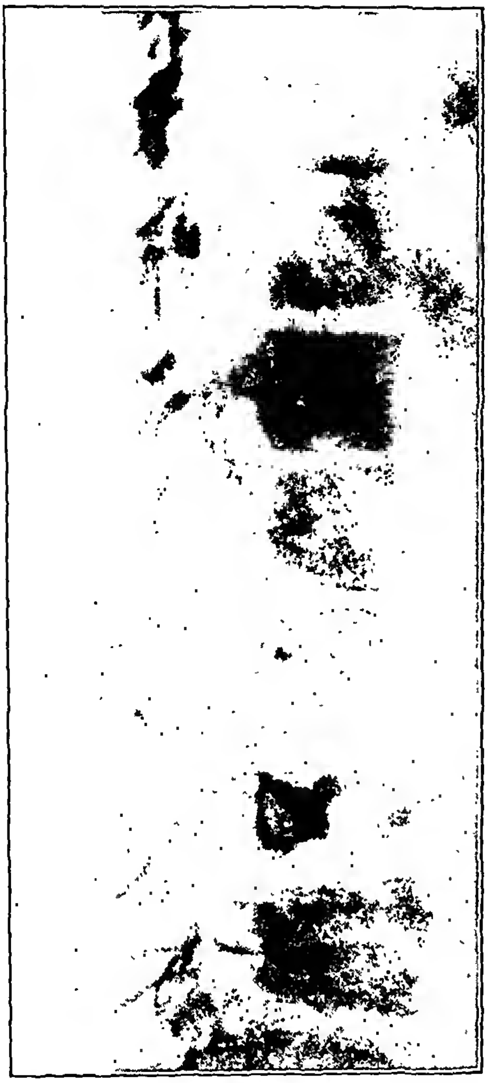

FIG. 8

Roentgenogram of the spine of a child, eleven years of age. The third and fourth lumbar bodies have collapsed and are fusing into a bony mass. Note that the posterior portions of the three bodies above this mass have degenerated areas with a small sequestrum in each. There is no collapse of these bodies, although the discs are somewhat thinned. An Albee bone-grafting operation was done in this case and subsequent roentgenograms show that these areas are filling in.

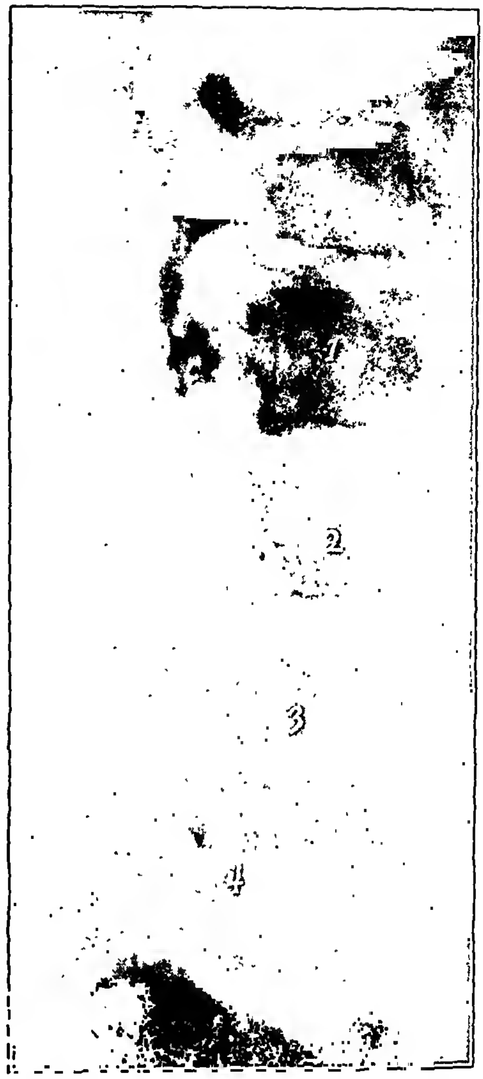

FIG. 9

Lateral roentgenogram of a colored female, aged thirty, showing tuberculosis of the spinous process of the second lumbar vertebra with destruction of the lamina and articular processes. Other foci were present in the bones and tubercle bacilli were found. There have been three similar cases, two of which were mistaken for malignancy.

losis of the spine admitted for care and treatment. Consequently an unusual opportunity has been afforded for studying the severe types of spinal tuberculosis and the end results of treatment. The accompanying roentgenograms, selected from these cases, illustrate the locations of the primary focus in the vertebrae and the character of the destructive process.

The usual site of the destructive lesion is the anterior part of the

Fig. 10

Roentgenogram of a boy, aged fifteen, showing destruction of the head and neck of the third rib on the right and of the spinous process, lamina, and transverse process of the first thoracic vertebra. As in the case shown in Fig. 9, this case was first thought to be malignant, but later tubercle bacilli were recovered.

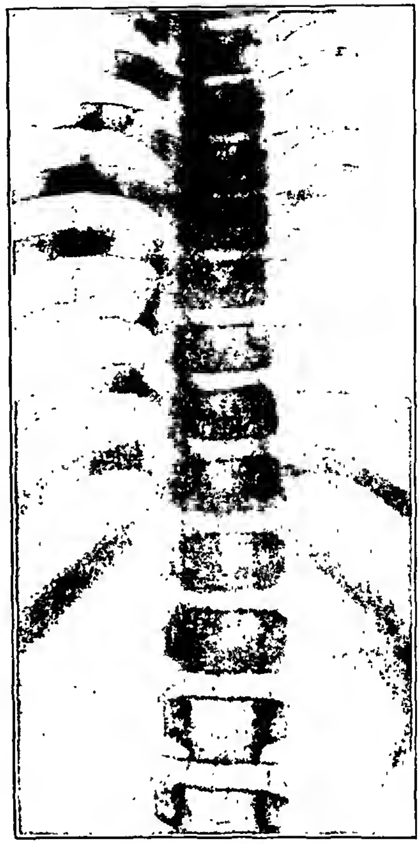

Fig. 11

Roentgenogram of a boy, ten years old, showing involvement of the head of the twelfth rib on the left. There is no narrowing of the disc, but a slight destruction of the left lateral wall of the twelfth centrum can be seen. There is no other tuberculous bony focus in the spine. Autopsy disclosed an abscess encircling the column of the centra from the seventh thoracic vertebra to the first lumbar vertebra.

centrum. Two or three adjacent vertebrae may be simultaneously affected. The process seems to spread up and down under the anterior common ligaments, infecting the centra above and below.

There are certain cases, usually in the low thoracic or lumbar region, in which the disease focus originates in the intervertebral disc and completely destroys the disc and the upper cortical plate of the centrum below and the lower cortical plate of the centrum above. (See Figures 1 and 2.) This type occurs both in children and in adults, and in children goes on to rather rapid healing without operation. In adults a fusion at the back is usually done, followed by support in a double spica jacket. About twenty cases of this type have been observed.

In the usual type, the destructive process destroys the anterior portion of the centrum and the discs intervening, as demonstrated in the mid-thoracic region of the spine shown in Figure 1. Occasionally, only the anterior portion is decalcified (Fig. 3) or the process may destroy one side of the centrum, causing a lateral deformity of the spine (Fig. 4). In some cases, the lower half of the centrum may be destroyed, and the disc persisting pushes upward into the softened bone (Fig. 5).

An example of the type in which the disease spreads under the anterior common ligament is shown in Figure 6. The disc is thinned, the anteroposterior diameter is diminished, and there is no collapse. In this case, the disease healed after ten years of treatment in the Sanatorium with head support but without operation.

The articular joints are very rarely the primary site of the tuberculous lesion. Figure 7 shows the only case that occurred in our entire series. The right articular joint beween the third and fourth lumbar vertebrae has been partially destroyed, and both bony processes show erosion.

Figure 8 illustrates cavity formation with small sequestra in three of the bodies; these sequestra are slowly absorbing after seven years of sanatorium treatment combined with an Albee bone graft.

Three cases have been observed at this hospital in which the tuberculous destruction originated in the spinous process. (See Figures 9 and 10.) This location of the disease contra-indicates the use of a bone graft because of the presence of pus in the operative area. These cases are of further interest because of the fact that two of them were mistaken clinically as well as roentgenographically for malignant disease.

In four of our cases, the tuberculous lesion was situated between the head of the rib and the vertebral centrum. (See Figure 11.) This location also complicates the problem of treatment.

It must be recognized that the roentgenogram does not always give positive evidence, for, at autopsy, vertebral centra are often found to be completely infiltrated with tuberculous material when previous roentgenographic examination has given no evidence of the disease.

OSTEOGENESIS IMPERFECTA

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Osteogenesis imperfecta is a disorder of bone formation in which increased fragility is the most important manifestation. The etiology is unknown. Key and Kersley believe that this disorder is due to "congenital instability of the mesenchyme". Weber's studies led to the conclusion that the functional location in this disorder is in the walls of the blood vessels and the composition of the intercellular substances. Kraus, and Wyatt and McEachern found evidence of changes in the glands of internal secretion. The deranged metabolism is poorly understood.

We have had the privilege of treating and studying, over a period of more than two years, a patient found to have osteogenesis imperfecta. A report of this case follows.

The patient is a female white child. Her birth at Jefferson Hospital was spontaneous and normal, and she was bottle-fed. The birth weight was six pounds and four ounces. On the sixth day a deformed left thigh was discovered. Roentgenographic examination revealed a fracture of the femur. Four other fractures, including a stellate fracture of the skull, occurred during the first twenty-seven months.

Family History

There is no history of chronic disease or of any abnormality of the skeletal structures of any member of the family, nor is there any tendency to fragility of bones or fracture. There is one brother in normal health. The mother, during pregnancy, was under observation in our Out-Patient Obstetrical Department and seemed in good health. During her convalescence, following the birth of the patient, the pulse rate averaged 90, but the temperature returned promptly to normal. Twenty-three months later, the mother was found to have definite moderate enlargement of the thyroid gland. The palms were warm and moist. She was nervous and irritable and had lost weight. The pulse rate averaged 100, and the basal metabolic rate was plus 48. The Wassermann and Kahn tests were negative. Gastric analysis of the mother, done several months later when the basal metabolic rate had returned to normal, resulted in a finding of free hydrochloric acid, ranging from 0 to 35, with a total gastric acid, ranging from 20 to 48 in terms of .1 normal hydrochloric acid per 100 cubic centimeters of gastric contents. Blood-serum determinations gave these findings: calcium 9.49 milligrams per 100 cubic centimeters; phosphorus, 3.3 milligrams per 100 cubic centimeters; and phosphatase, 3.9 units. The product of calcium and phosphorus equalled 31.3.

Physical Examination

The patient was somewhat undernourished. The sclera were definitely blue. The teeth were a dirty brown in color with only small areas of white in the outermost edges of the bicuspids. The incisors had no white areas. Both femora, tibiae, and fibulae were curved. The child could stand and walk with assistance. In walking, the right leg dragged slightly, probably the result of previous fractures. The child was mentally bright and physically active.

Results of Investigations of the Patient

The blood Wassermann and Kahn tests were negative. The Mantoux test was also negative.

The blood count showed:

Red blood cells—4,250,000

Hemoglobin—70 per cent.

Color index—.82

White blood cells—5,800

Polymorphonuclear neutrophiles—38 per cent.

Lymphocytes—59 per cent.

Examination of the stools revealed poor digestion of vegetables. They were light in color and pasty, and pH determinations over a two-week period gave an average of 4.4.

Gastric analysis resulted in finding a total acid range of from 1 to 3 with *no free* hydrochloric acid. This was in terms of .1 normal sodium hydroxide per 100 cubic centimeters of gastric contents. Gastric analysis with histamine injection gave a response of free hydrochloric acid from 6 to 35 and of total gastric acid from 9 to 50.

Metabolic studies were done on this patient over a three-day period. The diet was mixed but was considered to be adequate, although somewhat low in calcium content. Equal parts of all ingested food and water were used for chemical determinations of calcium, phosphorus, magnesium, and nitrogen. All faeces and urine were collected and analyzed for the same elements. Results of these studies are given in Table I.

TABLE I

RESULTS OF METABOLIC STUDIES

	Calcium (*Grams*)	Phosphorus (*Grams*)	Nitrogen (*Grams*)	Magnesium (*Grams*)
Food	.6116	.59443	3.9121	.3669
Urine	.00123	.14434	1.7924	.3147
Faeces	.14705	.40118	1.4190	.1817
Retained	.4656 (.0582 per kilogram)	.0489 (.0061 per kilogram)	1.0158	.1537
Comparison of amount in faeces to that in urine	120 : 1	2.8 : 1	.78 : 1	.57 : 1

The daily intake of calcium (.6116 of a gram) was low for a growing child, but the patient was given all the food, including milk, that she would take. The urine output was .2 per cent. of ingested calcium. The normal for infants is less than 5 per cent. The faecal calcium was 24 per cent. of ingested calcium. Calcium *retention* was .4656 of a gram, or .0582 of a gram per kilogram.

The phosphorus *retention* was .0061 of a gram per kilogram. This is somewhat lower than the normal for growing children, which has been determined to be .008 of a gram per kilogram. The *faecal* output is 2.8 times the *urine* output. Adults normally secrete approximately two-thirds of their phosphorus intake in the urine and one-third in the faeces. These findings indicate *deranged* phosphorus metabolism. There was definite nitrogen retention in this period of investigation.

Blood-serum determinations of calcium, phosphorus, and phosphatase were made at different intervals and under different conditions. During two periods in which *no* treatment was given, the serum calcium was normal and the phosphorus was *below* normal, with a calcium-phosphorus product definitely *below* normal. (See Table II.)

When dilute hydrochloric acid and vitamins A, B, C, and D were given, a much better digestion of food resulted, the stools became normal in appearance, and the pH changed from an average of 4.4 to an average of 6.1.

TABLE II

CHANGES IN BLOOD-SERUM VALUES FOLLOWING TREATMENT

Period No	Period Duration	Treatment	Blood Calcium	Blood Phosphorus	Product* Ca and P	Serum Phosphatase	Blood pH	Weight Gain (*Pounds*)
1		Bed rest following fracture.	10.28	*4.00*	41.12			
2	28 days	5 grains of calcium lactate every 3 hours.	11.09	5.40	59.80	5.6		0.5
3	8 days	1½ fluid drachms of super D daily.	10.48	5.93	61.83			1.0
4	7 weeks	None.	11.60	*3.40*	39.44			0.0
5	25 days	25 c.c. of .1 normal hydrochloric acid per 100 c.c. milk. Vitamins A, B, C, and D.	10.60	4.60	48.76	8.0		0.5
6**	50 days	15 c.c. of .1 normal hydrochloric acid per 100 c.c. milk. Vitamins B and D forced.						0.5
7	30 days	15 c.c. of .1 normal hydrochloric acid per 100 c.c. milk. 3 fluid drachms of cod liver oil daily. High-protein diet.	10.60	5.80	61.48	7.1	7.35+	2.0

*Explanation of products of calcium and phosphorus blood-serum values:
30—Diagnostic of rickets
30 to 40—No ossification
50 to 60—Normal

**During this period measles developed.

Gastric analysis was repeated after a three-day rest period following the courses of treatment previously described. Free hydrochloric acid was then present in the gastric juice and the total gastric acidity was increased. The stools became darker in color and of normal consistency. Food was well digested. The average pH of the stools changed from 4.4 to 6.8. The results of the analyses are recorded in Table III.

Treatment

Following the metabolic studies, treatment consisted of dilute hydrochloric acid which was added to the milk, a *high protein* diet, and cod-liver oil three times daily. At the end of this period the blood pH was 7.35+, the *product* of serum calcium and phosphorus was a *high* normal, serum phosphatase [13] was increased over that of Period 2, and the food was well digested. The patient made her greatest weight gain, and there was roentgenographic evidence of increased bone density.

TABLE III

EFFECTS OF TREATMENT ON GASTRIC ACIDITY, pH OF STOOLS, AND DIGESTION OF FOOD

Period No.	Period Duration	Treatment	Gastric Acidity (Titration Method)	pH of Gastric Juice (Colorimetric Method) *	pH and Description of Stools	pH of Blood Serum
4	7 weeks		Free hydrochloric acid 0 Total acidity 1–3	Total acidity 4.3	Average pH 4.4 Stools: light in color, pasty, food poorly digested. Foul odor.	Not determined.
		After histamine injection	Free hydrochloric acid 6–35 Total acidity 9–50			
5	25 days	25 c.c. of .1 normal hydrochloric acid per 100 c.c. milk. Vitamins A, B, C, and D.	Free hydrochloric acid 0–16 Total acidity 5–34	Total acidity 4.6–3.0	Average pH 6.1 Stools: brown in color, normal in consistency, food well digested. Normal odor.	Not determined.
7	30 days	15 c.c. of .1 normal hydrochloric acid per 100 c.c. milk. 3 fluid drachms of cod-liver oil daily. High-protein diet.	Free hydrochloric acid 0–6 Total acidity 6–11	Total acidity 3.4–2.2	Average pH 6.8 Stools: normal in color, consistency, and odor. Food well digested	7.35+

* Optimum pH for peptic activity and sufficient to produce secretin and to inhibit bacteria is below 3.[5, 10]

A tooth was extracted and examined histologically by one of us (H. E. R.), who reported as follows: "To the unaided eye the enamel is almost transparent and vitreous in appearance. The dentin, likewise, is almost transparent and the pulp, in the form of an opaque mass of comparatively large size and almost cylindrical in form, is readily discernible and extends far into the enamel end of the tooth. The dentin, macroscopically, is of a dirty white color with a slight yellowish tinge. Upon low magnification (×15) the semitransparency is enhanced.

"The tooth cut easily with a saw and although the pieces seemed hard to the touch they were quite soft and were easily ground.

Fig. 1

In the photograph (×4), the pulp cavity (*A*) is evident. This is due to the transparency of the tooth.

"Microscopically the enamel cuticle was well preserved along the sides of the sections and the deeper portion showed the continuations of the enamel rods. The layer of enamel on the occlusal surface is thin and irregular in spots; the enamel rods are straight, regular, and of uniform thickness, exhibiting very few irregularities in outline. The 'brown striae' are absent and the 'lines of Schreger' are almost wanting, being poorly represented near the occlusal surface. There is some brownish discoloration toward the surface of the enamel but this is diffuse in arrangement and not in the form of striae. The interglobular-space region is unusually wide but otherwise exhibits nothing unusual.

"The dentin, under low magnification, exhibits lines of varying widths which course parallel to the surface of the dentin; these seem to indicate varying positions of the dental papilla during the formation of the dentin. Their varying widths seem to indicate varying lengths of time in these *stop* or *rest periods.* The dentinal tubules, however, pass uninterruptedly through these lines and likewise show no alterations at these points. It would seem that these lines represent faults in the intertubular dentin.

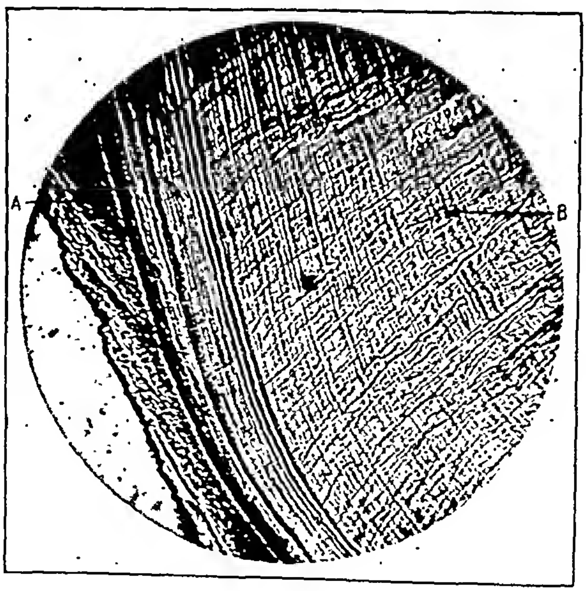

Fig. 2

Photomicrograph (16 mm. obj. × 10 ocular).
A: Enamel showing brownish pigment.
B: Dentin showing the *apparent rest lines.*

"The dentinal tubules are also peculiar for several reasons. They are quite large in diameter, irregular in course, and irregular in distribution; they seem to be arranged in bundles of different sizes and consequently the intertubular dentin is more abundant in some areas than in others. These tubules branch freely especially near the pulp cavity and many of the branches are recurved.

"The structure of the cementum is not so sharp and clear as in the normal tooth; the lamellae are poorly developed, especially superficially. The material seems granular in nature as though the chemical process

by means of which it had been laid down was incomplete. The cementum seemed quite soft and fragmented readily in grinding. It resembled, in structure and appearance, the bone of amphibians and birds."

DISCUSSION

The etiology of osteogenesis imperfecta has never been determined. The mother of this patient, twenty-three months after the birth of the child, was found to have an enlarged thyroid, increased basal metabolic rate, and increased pulse rate. The thyroid enlargement was probably present during pregnancy and we have some evidence that there was an abnormal secretion during this period. Unfortunately, no determinations of the basal metabolic rate were made and no thyroid disturbance was suspected. It is known that toxic thyroid patients have high excretion of calcium and phosphorus and normal blood-serum calcium and phosphorus[1,9]. There is also a tendency to the production of osteoporosis of the bones. It has also been determined that the majority of toxic thyroid patients have low gastric acidity or complete achlorhydria. Approximately one-third of these achlorhydric patients remain so even after histamine injection; in other words, one-third are truly achlorhydric.[2] Tibbetts, McLean, and Aub found that the high calcium and phosphorus excretion is not due to vitamin-D deficiency, and the major factor in producing diminished secretion of hydrochloric acid is the abnormal overactivity of the thyroid gland. The thyroid disturbance of the mother was probably an etiological factor in the deranged metabolism of this child. It is interesting to note Robison's finding that phosphatase, believed now by some to be important in the deposition of bone, is definitely *inhibited* by protoplasmic poisons.

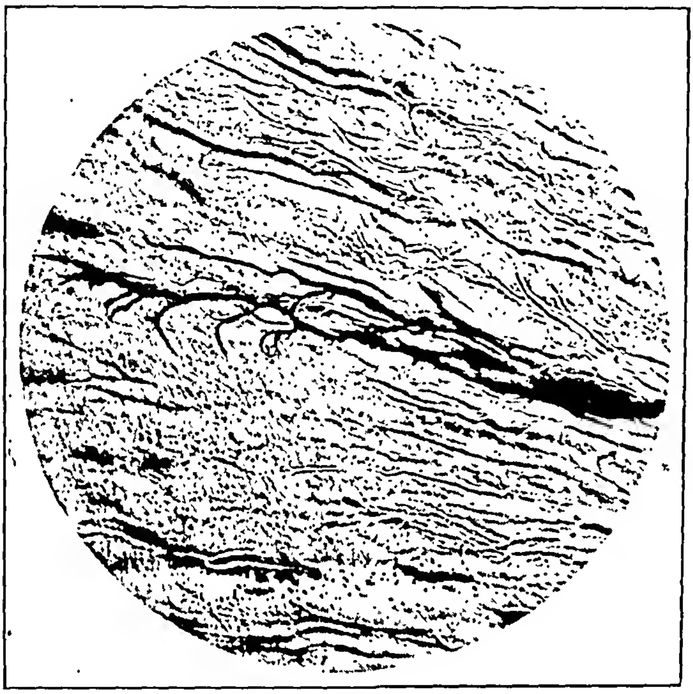

FIG. 3

Photomicrograph (4 mm. obj. × 10 ocular) of the dentin, showing the unusual branchings of some of the dentinal tubules.

This patient was found to have an absence of free hydrochloric acid throughout the digestive cycle when not under treatment; there was poor digestion of vegetables particularly, with tendency to fermentation in the stools. Some stools were pasty and light colored. There was good reten-

tion of calcium with a proportion between the faecal and urine output approaching the normal for adults. This was on a diet low in calcium for growing children [12]. The phosphorus retention was somewhat below the normal range for growing children (.0068 to .0C8 grams per kilogram) and the proportion of faecal to urine phosphorus output was reversed from the normal found in adults [16]. The blood-serum calcium was normal, serum phosphorus was constantly *low* in the absence of treatment, and the product of calcium and phosphorus was *below normal.* In the absence of treatment, no weight gain or roentgenographic evidence of improved skeletal change resulted.

It is a well-known fact that hydrochloric acid in gastric juice aids peptic digestion. The acid stomach contents stimulates secretions from the duodenum, the liver, and the pancreas. The acid contents of the duodenum should result in the formation of soluble acid calcium and an increase in calcium absorption. Conditions favorable to calcium absorption, in this respect, result in the absorption of phosphorus by increasing its solubility. This reduces the amount excreted in the faeces.

This patient also gave evidence of abnormal metabolism of calcium and phosphorus *after absorption.* In both periods of study when no treatment was given, the serum calcium remained in the normal range, but the serum phosphorus was low and the calcium-phosphorus product below normal. After the administration of vitamin D for eight days, the serum phosphorus was elevated and the product of calcium and phosphorus fell within the range of high normal. This represents the *intermediate* metabolism which vitamin D is known to affect so advantageously.

Peters and Van Slyke state that calcium chemically in the body may be looked upon as playing a *passive* rôle at the mercy of the proteins, phosphorus, pH, and other ions. Phosphorus, on the other hand, exists in a multiplicity of forms independent of calcium, all of which may become *inorganic.* The retention, excretion, and deposition of bone depend on the state, concentration, and supply of inorganic phosphorus. In nutrition the organic compounds of phosphorus are known to excel inorganic compounds even when the latter are given with other foods [12]. Phosphorus in organic compounds exists as nucleoproteins, phosphoproteins, phospholipins (caseinogen and ovalbumin).

In our patient the state of available phosphorus was for the most part *organic.* We have attempted to supply this organic phosphate in large quantities by instituting a high-protein diet and to effect adequate digestion and absorption of the proteins by the administration of hydrochloric acid. Vitamin D was added in the form of plain cod-liver oil and was shown in our particular patient to have a favorable effect upon the concentration of serum phosphorus.

It seems probable, in the light of our present knowledge [3], that phosphatase is an important factor in the deposition of bone or in the synthesis of phosphorus compounds in bone formation [4]. Phosphatase was found to be present in the serum in normal quantity after treatment.

Results of Treatment

Fifteen cubic centimeters of .1 normal hydrochloric acid per each 100 cubic centimeters of milk, three drachms of cod-liver oil daily, and a high-protein diet resulted in a weight gain of two pounds in the thirty-day period. This far exceeded the gain of any other period during observation. Other clinical evidences of improvement following treatment were: (1) whitening of the teeth, (2) definite fading of the blue color of the sclera, and (3) increased physical activity. Laboratory evidences of importance were: (1) elevation of serum phosphorus from 4.6 to 5.8, (2) elevation of the calcium-phosphorus product from a definitely low figure to a definitely high normal, and (3) roentgenographic evidence of increased bone density of the concentric type.

SUMMARY

Investigations of a patient with osteogenesis imperfecta revealed deranged primary and secondary phosphorus metabolism. Absorption and retention of phosphorus were below normal. The blood-serum phosphorus was low and the product of serum calcium and phosphorus values was below normal.

The tooth was defective in development, particularly the dentin and the cementum, both of mesodermal origin. The enamel, of ectodermal origin, was softer than normal and the "brown striae" and the "lines of Schreger" were absent.

The gastric secretion contained no free hydrochloric acid and low total-acid values. This was probably a factor in the poor absorption of phosphorus.

The mother of the patient was found to have hyperthyroidism which was probably an etiological factor in the abnormal bone development and in the abnormal gastric secretion of the child.

The administration of dilute hydrochloric acid and a high-protein diet, to provide phosphorus, and cod-liver oil, for its effect on secondary metabolism of calcium and phosphorus, resulted in better digestion of food, a normal product of serum, calcium, and phosphorus values, and clinical and roentgenographic evidences of improvement.

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OPERATIVE TREATMENT OF TUBERCULOSIS OF THE KNEE JOINT

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For many years the extensive resection of joints was regarded as the classical treatment of bone tuberculosis. The result was that in many cases the articular extremities were sacrificed, with so much separation of the surfaces that union was difficult. Also, at that time, the technique of fixation was imperfect and the subsequent course was not satisfactory. The open method of treatment of these wounds practically always resulted in secondary infection with its unfortunate sequelae; in most cases the patients were left with extremities poorly adapted for function because of the marked contraction.

Later, after Rollier had published his remarkable results obtained by the conservative method, resections were less and less practised and most surgeons became adherents of the conservative treatment. Rollier's slogan was: "Every case of tuberculosis can be healed if we have only the patience not to operate." His method consisted essentially of heliotherapy at high altitudes, with immobilization in recumbency but without plaster. Heliotherapy, either at high altitudes or at the sea, combined with immobilization by plaster or by traction, then became popular. The favorable early results obtained from this treatment gave an impetus to the conservative method and made it predominant over a long period.

However, continued experience showed that, after a few years of conservative treatment, relapses occurred in a large percentage of cases in which healing had apparently taken place and also that many times, although the pathological condition had healed, the patients were left with limbs unsuited for active use. Surgeons then began to return by degrees to the operative method, combining the conservative and operative procedures. In contrast to their former attempts to remove as much as possible of the bone which appeared affected, it now became their aim to create an ankylosis in the position of election. Moreover, with the recognition of the importance of careful postoperative immobilization, the results became increasingly better, and at present there have accumulated the records of a large number of cases in which this treatment has attained permanent success and from which definite conclusions can be drawn.

Since 1930, when Hibbs had reported 154 cases of operation with good results, a very large number of cases treated with success by the operative method have been recorded by Sorrel, Martens, Calvé, Vaccelli, Henderson, Frédet, Vignard, Maffei, LeFort, Odasso, Mezzari, Rose, Kornev, Friedland, and Frumin. The author's personal experience with the operative method consists of 109 resections performed during the period extending from 1921 to 1934. In comparing the results of the conservative and the operative methods of treatment of tuberculosis of the

knee joint, Martens, of the Göttingen Clinic, gives the following data: of eighty-six cases treated conservatively, good results were obtained in 41 per cent.; of 105 cases treated by operation, good results were obtained in 77 per cent.

Some surgeons continue to recommend conservative treatment, but an increasingly large majority are advocating operation with the object of attaining ankylosis. The important problem today is the estimation of the indications for operation.

At the second Ukrainian Congress of Surgeons, the late Prof. R. R. Vreden reported forty-five cases of fixation by his method, with excellent results. Mention should here be made of the difference between his method and that of Robertson Lavalle. While at first it may seem to be a modification of the Robertson Lavalle method, it has little or nothing in common with that procedure. Robertson Lavalle's technique is based on the supposition that around the infected area there is created a diminution of the blood circulation, a venous stasis, which it is advisable to relieve by drainage. This he accomplishes by making a canal in the bone to the area of infection, and into this canal he inserts a thin lamella of bone to act as a drain. This is by no means a simple procedure, for the focus may be situated outside of the area of stasis, and the object of the operation may not be attained. Independent of the question of the correctness of this method, it must be recognized that it is extremely difficult to determine the location of these foci roentgenographically, and one must be guided entirely by roentgenograms. Often this evidence does not correspond with the clinical picture, and it is, therefore, very difficult to place a drain in or at the exact zone where it is required. This method, as practised by other surgeons, has not given as good results as those obtained by its author.

The nail fixation, a pin of bone, suggested by Vreden, is supposed to have a beneficial effect, on the one hand, by producing a hyperaemia in the region of the nail and, on the other hand, by causing immobilization. It must also be mentioned that this method of fixation has not been readily accepted by the majority of surgeons, and it is now seldom applied. In three cases in which the author was obliged to operate, a fixation had previously been attempted and it was evident that it had contributed to an exacerbation of the process, which diminished only after a complete resection by the other method. One of the cases ended in amputation.

In the same way, the operation proposed by Prof. Kozlovski—an osteotomy above and beneath the joint, the so-called "osteotomia medicata"—has not justified itself by the results.

Before discussing the fundamental operations employed in the treatment of tuberculosis of the knee joint—the classical and the economic* resection—the removal of bone foci and synovectomy should be considered. Waldenström has performed a considerable number of synovectomies in

* This term is commonly used in the U.S.S.R. to denote a resection in which no attempt is made to remove all foci of disease or all of the invaded area.

cases of tuberculosis of the knee joint, always preceded by biopsy for accuracy of diagnosis. After ten years of experience with this operation, he arrived at the conclusion that the results did not warrant its advocacy. Calvé and Alglave also give unfavorable opinions in regard to it.

With reference to the elimination of isolated foci, it cannot be doubted that the early removal is of importance, and it is very evident that para-articular foci may sooner or later invade the joint, resulting in an explosion of the joint symptoms. This operation has not been accepted widely and little favorable comment in regard to it can be found in the literature. The principal consideration in regard to these isolated para-articular foci does not lie in difference of opinion as to when the operation should be done, but, rather, in the fact that they can seldom be seen clearly. Even when roentgenograms are taken in different positions, they frequently do not give the location accurately enough for operative interference. During operations on joints, large and small foci near the epiphyses are often found, which were not visible roentgenographically.

The question of the age at which operation is advisable is an important one and is particularly debatable in regard to children. Volkmann, König, and others have expressed doubt as to whether it is rational to operate on children because of the unfortunate results which sometimes occur. Kirmisson has strongly advised against operating on children, and many of the French orthopaedic surgeons are still opposed to it. Calvé and Galland, in 1925, formulated their opinion in regard to this question as follows: "*Ne jamais réséquer l'enfant, réséquer en principe l'adulte, ne pas tenter la résection chez le vieillard.*" Up to the present time, Calvé does not operate before the age of twenty. Sorrel gives the following formula: "*Chez les enfants, immobilisation; chez les adultes, résection; chez les vieillards, amputation.*" However, in studying his material, it will be seen that of 120 resections, seventy-two were performed on persons under the age of twenty, among whom were eight not yet sixteen years old and twenty-five not yet seventeen years. Therefore, it would seem that he has considerably modified his indications. Girdlestone is apparently of the same opinion, as he advises the surgeon to "avoid operating on very young, very old, and very weak persons". Spitzy prefers to operate only after bone growth has been completed. Krasnobaev is also an adherent of operative treatment of tuberculosis in the knee joint in adults. "It is quite incomprehensible," he says, "how surgeons who have to do with adults can ignore operative treatment as they well know how much strength and time must be wasted by an adult patient in order to remain the winner in the struggle with bone and joint tuberculosis when treated by the conservative method." With regard to children, however, he takes a different view and states: "The experience of the older surgeons who have won good reputations for resections in cases of knee tuberculosis is very great and sufficiently convincing to transfer the indications for this operation to the infantile age, at least from thirteen or fifteen years."

A large number of outstanding orthopaedic surgeons have gradually extended their indications for economic resections in children. The essential requirement is that the epiphyseal cartilages should not be injured.

At the last International Antituberculosis Congress in Warsaw, Maffei stated that he operated on children at the age of five years and that there was no danger of injuring growth, provided that the epiphyseal lines were not damaged. However, in the ease of a considerable contraction, especially of a subluxation, it would be extremely difficult to perform an economic resection of the knee of a child without damaging the epiphyseal lines. Therefore, it is of the utmost importance to prevent the development of a contraction.

Among the Russian authors, Kornev has collected a large amount of data in regard to knee resections during infancy. He operated on children of less than ten years of age. In 1930 he reported that 23 per cent. of his resections were in children less than ten years old and that 41 per cent. were in children from ten to fifteen years of age. In other words, 64 per cent. of the resections of the knee were in children less than fifteen years of age. From periods of observation ranging from one to seven years, he has found that the average shortening in these cases was five centimeters. He, therefore, concludes that this age should not be considered a contra-indication for performing an economic resection.

If we bear in mind how often the paths of infection pierce the epiphyseal lines, destroying them to a great extent, we may well conclude that the adherents of economic resection on children have good reason for operating at an early age, provided that they do not injure the epiphyseal cartilages. Moreover, one may well question whether it is rational to wait eight, eleven, or even fifteen years to perform the operation, when, during these years, there may be inflicted on the epiphyseal lines much greater injury by the destructive process than might be caused by an operative interference cautiously carried out. Finally, one should consider whether the shortening produced by conservative treatment is much less than that caused by an economic resection.

The other important question to be determined is the stage of the disease at which it is preferable to operate. The majority of surgeons are of the opinion that the period of abatement of the process is the most suitable. Sorrel's answer to the question is as follows: "*Il ne faut pas opérer les tuberculeux jeunes; il faut les laisser vieillir.*" Of the same opinion is Calvé, who states: "*Mes résections sont toujours tardives.*" In general, he believes that operation should not be performed until two years after the onset of the disease. Kornev and Lourie also advise against operative treatment during the initial stages of the process.

However, a number of experienced orthopaedic surgeons, principally Americans, advocate operative interference as early as possible. Hibbs, Allison, Osgood, and Henderson have advised such interference as soon as the diagnosis has been determined. Yessipov thinks an operative interference is necessary in children "in cases of open fistulae with secondary

infection in the great joints; in the presence of sequestra; when the conservative treatment has been prolonged and shows no progress; and when the strength of the child is evidently exhausted". He further states that "operative interference in cases of fistulae in the joints consists of a radical resection of the joint, taking care not to injure the epiphyseal cartilage. Therefore, if possible, the operation should be performed according to the economic type." Kornev also does not consider that the presence of fistulae is a contra-indication for resection of the knee. Maffei operates not only during the period of abatement, but also during the stage of development of the disease. However, he does not advocate operating during the acute period, preferring to delay operative interference until at least six months after onset of the disease. He lists the following conditions as contra-indications: an acute period of the disease; simultaneous affection of the lungs, the kidneys, and the intestines; fistulae with secondary infection; cases in which it is clear that ankylosis is developing; doubtful cases in which after some months of quiescence there seems to be full recovery; and cases in which the temperature is above 38 degrees centigrade.

In this discussion of the technique of operative interference in tuberculosis of the knee joint, it is the author's purpose to consider the classical resection and the so-called economic resection or arthrodesis. It seems unnecessary to consider the introduction of drugs into the joint cavity, removal of para-articular bone foci, or excision of the synovial membrane. While the majority of surgeons think it necessary to remove carefully all affected soft tissues and joint ends, together with the patella, just as if they were a malignant neoplasm, others believe this to be entirely superfluous. Although a supporter of the simple classical resection, Sorrel endeavors to remove all soft tissues, together with the patella. Basset, Frédet, Waldenström, and Calvé remove the capsule and the patella. Kornev employs the same technique except that he removes the portion of the patella next to the affected joint, leaving the upper part in place. Mezzari opposes resection and prefers extra-articular arthrodesis according to the method of Delahaye-Zanoli. Putti also favors extra-articular arthrodesis. Waldenström removes the capsule and the patella like a neoplasm and resects the tissues high up on the femur behind the condyles. The extremity is then encased in plaster and placed in a slightly raised position. At the end of three months the patient is allowed to bear a little weight on the foot. After from eight to ten months, the plaster bandage is replaced by a leather case.

Although formerly it was considered essential to remove the foci of infection, together with the surrounding bone, at present the procedure is confined to a more or less elaborate scraping out and packing of the cavity. Kornev fills the cavity with a soft iodoform-vaselin paste; Friedland uses sterilized vaselin or autoplastic fat; Frumin swabs with liquid carbolic acid which is then neutralized by absolute alcohol; and others pack the cavity with bone chips.

TABLE I

AGE INCIDENCE

Period (Years)	No. of Cases
8 to 10	3
10 to 15	7
15 to 20	56
20 to 25	37
25 to 45	41
45 to 53	3
Total	147

The tourniquet may or may not be used, according to the preference of the operator. The section of the bone is done in several different ways. Calvé uses a double parallel saw which permits the proper correlation of the bone surfaces. Kornev saws the bone in the form of an arch, which makes it possible to resect a smaller piece of bone, thereby producing less shortening. Sorrel generally resects less than five centimeters on the tibial side and three centimeters on the femoral side. Only a few surgeons (notably Leriche and Henderson) resort to fixation with the aid of clamps or metal wire, most surgeons now believe this to be not only unnecessary but even inadvisable, because of the protracted osteomyelitis which occasionally follows. A position of slight flexion is desirable; great care should be taken to avoid the position of genu recurvatum. It is very important that the knee should be held in the desired position and that the cut surfaces should not be displaced. Such displacement can be avoided, to a certain extent, by carefully sewing with strong catgut the rims of the periosteum which have been turned back. A plaster bandage, with a thin layer of cotton-wool, is then applied to the limb, including the foot and the pelvis.

There is no unanimity in regard to the question of whether or not a drain should be left after the operation. The majority of operators do not leave either a drain or a tampon.

The period of immobilization varies with the different operators, but the tendency is toward long-continued fixation. Sorrel removes the belt at the end of two months and changes the other part of the bandage a month later. If full consolidation has not taken place at this time, he recommends the wearing of a plaster splint for an additional two months, followed by a celluloid apparatus. This latter piece of apparatus may usually be discarded in a month. Calvé immobilizes the leg for three months and then, if sufficient ankylosis has developed, he allows weight-bearing without any apparatus. However, if there is evidence of any mobility, a plaster bandage is reapplied and the patient is permitted to bear weight on the foot.

TABLE II

DURATION OF DISEASE BEFORE OPERATION

Years	Cases
2	3
3	8
4	10
5	12
6	10
7	12
8	11
9	15
10	29
11 to 20	31
20 to 30	6
Total	147

Of the total number of patients with bone tuberculosis who have been treated in the Out-Patient Department of the Orthopaedic Clinic of the Kharkov Medical Institute during the period from 1921 to 1936, 609 had tuberculosis of the knee joint; of these, 147 were treated surgically. At first, operations were performed only on adults and in cases where the disease had abated. Later, we very cautiously extended the indications, both in regard to age and the stage of the process. We did not risk operation in the initial stages, but we began to operate in the developmental periods. Table I shows that the number of children under fifteen years of age was not large, but that the greatest number of patients operated on were between the ages of fifteen and twenty years. There were sixty males and eighty-seven females.

Operations were never performed until at least two years after onset of the disease. Table II shows that in nearly 45 per cent. of the cases the disease had been in progress ten years or more before operation. The pathological indications were as follows: contraction, 90 per cent. of the cases; subluxation, 20 per cent.; full luxation, 1 per cent.; fibrous ankylosis, 70 per cent.; osseous ankylosis with pathological signs, 30 per cent.; and a local rise in temperature, 50 per cent. In fifty-four cases, the resected tissues were examined microscopically and the diagnosis of tuberculosis was not confirmed in only six cases.

In principle, the technique of resection followed at our Clinic differs little from that used by other surgeons. While earlier we carefully resected the capsule, we now confine ourselves to removing a wedge of bone which includes the affected joint. The wedge should be of such shape and size that it may be set in the position of slight flexion. The size should be calculated as accurately as possible in order to obviate later correction by sawing off new pieces of bone. If areas of pus or cavities filled with granu-

lated masses are found, they are resected. The resection may be slightly modified according to circumstances, but, in principle, it remains essentially an economic one.

It is easily understood that in cases of considerable and obstinate contraction with subluxation a large piece of bone must be resected. However, in cases in which the contraction can be corrected by a series of preliminary bandages, such correction is advisable in order to limit the amount of bone to be resected. Moreover, section of the flexors and the tensor fasciae latae renders it easier to place the leg in the required position. Severe and obstinate contractions in children present grave difficulties, because of the danger of injuring the epiphyseal cartilages. However simple the operation of economic resection may be in the case of a small contraction, it always becomes difficult when the contraction is marked; in such a case the saving effected by the making of an arch does not help much.

We have never used any pins for fixation, but have utilized with success a method proposed by Sorrel,—namely, the drawing back of the periosteum along the line of incision and sewing it together again after the operation. This facilitates the union in the correct position of the cut surfaces. Sutures of strong catgut provide sufficient fixation.

With a chisel, a piece of bone, corresponding in size and form to the cavity, is cut from the sound part of the resected bone or from the patella and, after the cavity has been thoroughly curetted, this piece of bone is pressed into it. If the cavity is large, several chips of bone are necessary to fill it. In no case has this graft failed to unite, nor have complications followed. In the majority of cases the cavities are either invisible or seen dimly in the roentgenogram; usually they are filled with purulent or granulated masses. During the last few years, it has been our practice to leave in a tampon for twenty-four hours to prevent the development of hematomata.

The operating table has a support for the pelvis-holder; therefore, it is not necessary to transfer the patient from one table to another. A broad splint in the form of a trough serves for preliminary fixation. The plaster bandage which encloses the pelvis and the foot is put on with a small quantity of cotton-wool in such a manner that the plaster may be modelled carefully.

At the end of approximately six weeks, the patient is permitted to walk on crutches and to bear weight slightly on the affected leg. Three months after the operation, the plaster bandage is shortened, or replaced by a new bandage without a belt. This second bandage is worn for an additional three months. During this period the patient may bear weight freely on the leg. At the end of this time, a removable bandage, made of plaster and gelatin or of gelatin and formalin, is applied. The length of time during which this apparatus is worn is governed by the firmness of the ankylosis and by the evidence furnished by control roentgenograms.

In a large number of cases, for several days after the operation, there

was a rise in temperature, but this was only transient and the temperature became normal in the course of two or three days. In the rare cases in which operation was performed at a relatively early stage of the disease (two or three years after onset) this rise in temperature lasted for from one and one-half to two months.

In a number of cases an ideal adjustment of the resected surfaces was not obtained, but this did not noticeably affect the stability of the extremity. In some cases it was necessary to correct the position after operation. This was difficult to do and was accomplished by changing the position of the bandages. The length of time required for firm ankylosis varies and is governed by a number of factors,—accuracy in the adjustment of the cut surfaces, the age of the patient, maintenance of fixation, the stage of the process, etc.

Of the 147 patients operated upon (five amputations and 142 resections), we have written reports on forty-eight, and fifty-five have appeared for examination. Two patients had died two years after operation; in one case death was due to accidental infection and in the other to tuberculous meningitis. In both cases, however, complete healing of the gonitis had occurred. In the other forty-six cases, good results had been obtained and the patients had returned to normal life. The fifty-five patients who appeared for examination were all in excellent condition.

An excellent result was obtained in the case of a female patient, aged fifty-three years, in which the cut surfaces were like honeycombs filled with purulent matter. Fibrous ankylosis occurred in only two cases, but both of these patients reported that they felt well.

Among the patients operated on at other institutions was a female, forty-nine years old, whose knee had been resected at the age of nineteen. The position of the joint is excellent and there is shortening of only four centimeters. There is full function and her only complaint is of general fatigue in the leg after walking for a long time.

In one case, three years after a "nailing" operation had been performed, union had not taken place and fistulae had formed with persisting pain. Roentgenographic examination showed atrophy of the joint surfaces and in the background a long pin jutted out. This patient decided upon amputation.

At resection of the knee joint of another patient, an ivory pin, surrounded by granulations, was found. The canal was carefully cleaned and the resection was performed. The postoperative period was uneventful with the exception of a somewhat protracted period of fluctuations in temperature. At the end of a year ankylosis had not taken place and the knee was slightly painful and could not be used normally. Amputation was, therefore, decided upon.

The author resected the knees of two other patients who had previously undergone the "nailing" operation and ankylosis had not taken place. Following resection, firm ankylosis developed and both patients have returned to work.

In the ten cases in which resections were performed on the knees of

children under fifteen years of age, there was grave danger of injuring the epiphyseal cartilages, due to the acute angle of the contractions which necessitated the removal of large pieces of bone. However, control roentgenograms taken immediately after operation showed that the epiphyseal cartilages had not been damaged. Further study disclosed the disappearance of atrophy. In regard to the sequelae of our resections on children, we must mention a certain tendency toward the development of an angle of flexion at the area of ankylosis. This is to be explained by disproportionate growth of the epiphyses, a phenomenon that is often met with in cases of tuberculosis of the knee joint. Taking this tendency into consideration, at present after an operation on a child, we always fix the extremity in a straight position, and not at a slight angle as in an adult.

In the case of a female, operated on in 1905, the roentgenogram (Fig. 1) showed the structure in the region of the lower part of the femur and the upper part of the tibia to be homogeneous and the cortex well defined.

Fig. 1

The stability of the leg and the sensations of the patient are just the same whether or not the patella has been removed. There were only two cases in which shortening amounted to seven centimeters; in the other cases it averaged between three and four and five-tenths centimeters. However, the shortening of seven centimeters did not inconvenience the patients, although their occupations involve physical labor.

CONCLUSIONS

1. In treating tuberculosis of the knee joint, the best results are obtained by operative intervention.

2. At present we are not concerned with the question of whether or not an operation should be performed, but with more accurate indications for the operation.

3. Adolescence and maturity are the most suitable ages for operation. Excellent results have also been obtained in old age. Evidence has also been accumulating which indicates that economic resection may be successfully performed on patients between the ages of ten and fourteen, if care is taken not to injure the epiphyseal cartilages.

4. The best time to perform an operation for ankylosis is the period of abatement of the process. The initial stages of tuberculosis in the knee joint are not suitable for operation.

5. The success of operative interference does not depend upon the removal of all affected tissues. The operation should be a simple one, aiming chiefly at the formation of ankylosis. The bone foci should be thoroughly curetted and filled with bone chips.

6. No clamps, braces, or wires should be employed, but it is important to fix the knee in a position of slight flexion.

7. Neither the operation of Robertson Lavalle, nor "nailing", nor "osteotomia medicata" is to be recommended in cases of tuberculosis of the knee joint.

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NOTE: The subject of low-back derangement is occupying the attention and enlisting the interest of a very large number of orthopaedic surgeons, and the difficulty of differentiation of the various conditions causing low-back pain and resulting from low-back strain is fully recognized. At the Meeting of the American Academy of Orthopaedic Surgeons, held at Cleveland in January, a symposium on this subject was conducted. The papers presented at that symposium are published in this issue as a group, with the concluding remarks of the Chairman, Dr. Joel E. Goldthwait, whose name has been so intimately and for so long a time associated with this particular problem.—*Editor.*

LOW-BACK PAIN

THE ANATOMICAL STRUCTURE OF THE LUMBAR REGION, INCLUDING VARIATIONS *

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To understand properly the anatomical structure of the lower back, and to appreciate its susceptibility to aches of obscure etiology, consideration must begin, not with the cadaver on the dissecting table, but with the ancestral spinal column from which that of man has evolved, and with the manner in which the lower extremity develops and becomes attached to the vertebral column.

In early foetal life the ilia, developing in the hind-limb buds, approach the vertebral column and become attached to the transverse processes of one or more vertebrae. These, assuming such special responsibility, enlarge, fuse, and become the sacrum. The points of attachment become the sacro-iliac joints.

Within each animal species there is variation as to the particular vertebrae with which the ilia articulate, and this variation is frequently bilaterally asymmetrical. In addition to such individual variability, there is either progressive or retrogressive fixation of the pelvic complex to the vertebral column, appearing in different zoological species derived from common ancestral types.

In the evolution of man, the pelvis has progressed toward the head by incorporation in the sacrum of successive last lumbar vertebrae, the next preceding segment thereupon assuming the characteristics of the last lumbar segment. At present, the human spinal column has a modal number of twenty-four presacral segments, varying to twenty-five in 3.5 per cent., and to twenty-three in about 1 per cent.

Of more interest in the present clinical discussion than simple addition to, or subtraction from, the length of the presacral column are the much more common partial sacralizations and lumbarizations. Whether the involved segment be the twenty-third, twenty-fourth, or twenty-fifth is of little importance. Such anomalies are manifested by enlarged trans-

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verse processes on one or on both sides of the last lumbar segment, which may impinge on, articulate, or fuse with the lateral mass of the sacrum, or articulate with the ilium. Another evidence of partial sacralization is variation in conformation of the articular processes, and in their planes of incidence, between the sagittal lumbar and the transverse sacral types.

Still a third manifestation of partial sacralization of a last lumbar segment, and one that is often wrongly interpreted as a pathological lesion, is narrowing of the lumbosacral disc. In anomalous sacralization, the vertical diameter of this disc may vary between the diameter of the usual thick lumbosacral type and that of the thin sacral disc. A thin disc is in itself no proof whatever of a destructive or pathological lesion. Particularly, if such a disc is associated with enlarged transverse processes or other evidence of anomalous sacralization, as are most of those shown in clinical discussions, such pathological interpretation must be received with considerable reservation.

Partial sacralizations, in which the transverse processes of the last lumbar segment made actual contact with the sacrum or the ilium, were found in 7 per cent. of 748 vertebral columns examined. In this study it was impossible to determine the incidence of anomalous processes not making actual contact, because a normal from which variation could be measured could not be established. Such enlargement, however, was unmistakable in more than 15 per cent. of the vertebral columns.

A second type of anomaly of interest in low-back pain is defective development of a vertebral arch, particularly the arch of the last lumbar vertebra, with consequent break in bone continuity of the arch. This defect may appear centrally, as in spina bifida, or laterally, freeing the superior articular processes and the vertebral body, which supports the superincumbent body weight, from the inferior articular processes, which anchor this weight to the sacrum and to the pelvis. When such a defect is bilateral, stability of the torso on the pelvis depends entirely upon fibrous attachments between the fragments of the arch.

This anomaly has been found at this site in about 6 per cent. of dissecting-room subjects. It has been interpreted as fracture of the arch, but this explanation does not seem probable for the following reasons: (1) in about 25 per cent. of the cases the anomaly appears unilaterally; (2) the laminae affected are often defectively developed; and (3) in no instance so far reported has there been evidence of attempted bone repair, even in the unilateral type.

The spinal column of the newly born human, like that of the quadruped, presents a single curve,—a backward convexity. When the infant extends his neck, a cervical curve develops, and when he extends his hips, a lumbar curve is present. As he sits upright, the cervical curve becomes established, and as he walks, the lumbar curve becomes fixed, although the adult type of curve is not fully impressed for several years.

The 90-degree adjustment of the human back to the upright posture is accomplished partly through increased extension of the hip joints, but

more through hyperextension of the lumbosacral and lower lumbar articulations. Extension of the hips stretches the anterior hip ligaments and muscles. Lumbosacral hyperextension stretches the anterior vertebral ligaments and muscles, compresses the lumbosacral intervertebral disc posteriorly, allows contracture of the posterior lumbar muscles and ligaments, and forces the inferior articular processes of the last lumbar vertebra downward over the superior processes of the sacrum. The less hip extension is developed, the greater must be lumbar hyperextension, or lordosis.

The sacrum is not wedged between the ilia like the keystone of an arch, but is slung between them on strong ligamentous and minor muscle attachments. Anteriorly, the short transverse sacro-iliac ligaments bind the bones together. Posteriorly, the sacrum hangs on tough fibrous bands extending between the rough iliac tuberosities and the back of the sacrum. Distally, the sacrosciatic ligaments help to stabilize the articulation.

In quadruped posture, the sacrum, slung between the hind-limb supports, carries only the weight of the distal part of the torso. In erect posture, it must also support the thorax, the head, and the upper extremities, all of which are half balanced on its proximal end. The mechanical strains resulting from this arrangement are terrific. Increasing lordosis not only increases the strain but, by approximating origins and insertions of the lumbar muscles, cripples the protective mechanism.

The clinical importance of lumbosacral anomalies and of postural variations is in direct proportion to the extent to which they weaken the part mechanically. The presence or absence of a lumbar segment is of little interest. Enlarged transverse processes, impinging on or articulating with the sacrum or the ilium, or variations in the planes of the articular processes are of importance only as sites perhaps abnormally susceptible to injury. To what extent such anomalies actually predispose to strains and sprains is problematic. Data recently furnished by Badgley and Hodges indicate that it is very little. The former, in a study of several hundred patients complaining of backache, found these anomalies in 26 per cent.; the latter, in the same number of patients without back pain, found them in 27 per cent. They were present in the same proportion of our dissecting-room subjects, some, but not all, of whom probably had low-back pain during their lives. The presence of such anomalies in the vertebral column, therefore, does not solve the problem of backache.

The bilaterally defective neural arch does weaken the anchorage of the torso to the pelvis at the point where the strain of the upright posture is centered. Such arches are definitely separated by injuries. Before separation it is difficult to distinguish them and they are, no doubt, frequently overlooked. Only a small minority of these arches found in the dissecting room have been separated or show spondylolisthesis.

With skeletal anomalies there are, of course, associated variations of the soft tissues, but nerves, muscles, and blood vessels develop with the anomalous bones and must, therefore, be adjusted to them. The butterfly

transverse process does not suddenly develop, pushing nerve trunks aside. The possibility that such processes cause enough tension on the nerve trunks to produce neuralgia or neuritis has been discussed in the medical literature. Analogy has been drawn between such a cause of sciatica and the cervical-rib syndrome. Sciatic pains have been relieved after removal of enlarged transverse processes, and brachial pains have been alleviated following release of tension over a cervical rib. On the other hand, both anomalies exist for years without symptoms, until the relation of nerve to bone is altered by changing posture. The pain in both conditions is often relieved by correction of the faulty posture. However, the treatment of this problem is a clinical consideration.

SUMMARY

The various tissues of which the lower back is composed are particularly liable to aches and pains because of the mechanical strains centered upon them by assumption of the upright posture and by the incidence at this site of anomalies and defects of development.

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THE OPERATIVE TREATMENT FOR LOW-BACK PAIN *

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The patients whose case histories were studied for this report were treated by several different surgeons of the University of Chicago Clinics. Only the author, however, can be held accountable for any theories expressed or conclusions reached in the course of this presentation.

So long as surgeons disagree in regard to the pathogenesis of chronic low-back pain, there cannot be any uniformity of opinion concerning treatment. The same indications for operative treatment are rarely stated by any two men who have written upon this subject. Each surgeon has his own explanation of the primary causes of low-back pain, his own program of conservative treatment, and, if operation is decided upon, his own pet variation in technique for carrying out his favorite operative procedure. Those surgeons who advise operation for almost every patient with a chronic lame back are considered to be extremely radical by those who do not operate at all. This question once more brings up the problem of whether or not the sins of omission, or failure to operate in low-back conditions in which there are definite indications for so doing, are greater than the sins of commission of those surgeons who are less critical in analyzing their patients to determine whether or not there are sufficient indications for surgery. There must be a middle road which it would be profitable for us to travel.

Many operations, involving separate principles and based upon individual hypotheses, have been devised and advised for the relief of low-back pain. The following are a few of those which have been described:

1. *Lumbosacral fusion*, by the method of Hibbs or Albee or by some modification of their techniques.
2. *Sacro-iliac fusion*, as described by Smith-Petersen, Gaenslen, and Campbell, or a modification of these methods.
3. *Trisacral fusion*, by the method of Chandler or by a combination of one of the techniques for fusing the lumbosacral or sacro-iliac joints.
4. *Facetectomy*, as described by Putti, Ghormley, Williams, Yglesias, and Mitchell.
5. *Section of the iliotibial band*, advised and described by Ober.
6. *Section of the piriformis muscle*, as described by Freiberg.
7. *Subperiosteal stripping of the gluteus maximus muscle*, suggested by Heyman.

The author's opinion as an individual can carry little weight, but the

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majority of those members of the American Academy of Orthopaedic Surgeons and of our colleagues in other countries who have written upon this subject have favored some type of arthrodesing operation, when surgery would seem to be definitely indicated.

An analysis has been made of all of the patients whose primary complaint on entrance to the University of Chicago Clinics was that of low-back pain. In this analysis, patients who were admitted primarily because of another complaint, but who subsequently received treatment because of backache, have not been included.

Of 139,000 patients registered at the University of Chicago Clinics between 1927 and 1936, 2242 came because of low-back pain. This is an incidence of 1.6 per cent., a figure which is far lower than the author had imagined, since backache is one of the commoner complaints of adult patients who enter our Orthopaedic Out-Patient Department. Seventy-six of the 2242 patients were subjected to operative treatment. This incidence of 3.4 per cent. indicates the conservative attitude which we have tried to observe toward the question of surgery for the relief of low-back pain. Of the seventy-six patients who were operated upon, there was definite pathology in forty-seven. This pathology consisted of spondylolisthesis, spinal-cord tumors, bone tumors,

TABLE I

ANALYSIS OF SEVENTY-SIX CASES TREATED BY OPERATION

DEFINITE PATHOLOGY—47 CASES

Pathology	Treatment	No. of Cases
Spondylolisthesis	Fusion of fourth and fifth lumbar vertebrae to sacrum	14
Lumbosacral or sacro-iliac tuberculosis	Fusion	8
Chronic osteomyelitis of the sacro-iliac joint	Fusion	6
Primary malignant neoplasms	Biopsy and x-ray therapy	4
Lesions of spinal cord or of the meninges	Laminectomy and partial or complete excision of tumor	15

CHRONIC STRAIN OR ARTHRITIS—29 CASES *

Operation	Joints Fused	No. of Cases
Arthrodesis	Sacro-iliac	7
Arthrodesis	Lumbosacral	10
Arthrodesis	Lumbosacral and one sacro-iliac	6
Arthrodesis	Sacro-iliac and symphysis pubis	1
Trisacral fusion		5

* These patients ranged in age between 13 and 54 years; the average age was 30 years.

tuberculosis, and chronic sclerosing osteomyelitis. In addition to these patients, there were twenty-nine who were operated upon because of the diagnosis of chronic strain, subluxation, or arthritis. The twenty-nine patients, who had only low-back pain without any roentgenographically demonstrable pathology and upon whom arthrodesing operations were performed, represent an incidence of 1.3 per cent. The fourteen patients upon whom arthrodesing operations were performed because of spondylolisthesis were improved or completely relieved. Including the twenty-nine cases in which there were no roentgenographic abnormalities other than common lumbosacral developmental anomalies, there were in our series fifty-seven patients who were subjected to arthrodesing operations. Two patients who were operated upon because of tuberculosis died subsequently of amyloid disease.

Of the twenty-nine patients upon whom were performed arthrodesing operations for chronic strain or arthritis, with or without congenital anomalies of the lumbosacral region, twenty-two were improved or made a complete recovery. There were seven failures, probably attributable to a poor selection of the cases. Four were patients with chronic arthritis which, at the time of operation, was thought to be localized to the low-back region, but which proved to be a progressive process and spread to other levels in the spine and in some instances to other joints as well. One patient was a compensation case and did not obtain any relief from the operation until after a satisfactory financial settlement had been made. This and similar experiences led us to adopt a policy of refusing to do arthrodesing operations on the spines of patients who were compensation cases until after settlement had been made. One patient was definitely a psychiatric case, although this was not recognized in time to prevent what proved to be an unsatisfactory operative procedure. In this instance, a trisacral fusion was carried out, but the patient continued to complain that her back was "twisted" and her hips were "lopsided" and, when she was discharged, she went to a hospital in the East where the trisacral fusion was again performed with the same degree of failure. There was one death on the third day after a trisacral fusion, as a result of circulatory failure.

Most low-back lesions can be localized to one or to both sacro-iliac joints or to the lumbosacral region by careful physical examination. The operation of trisacral fusion is in the nature of a shot-gun procedure and should rarely be advised.

Table II is included to emphasize the fact that not all patients with intractable low-back pain, which is not relieved by a conservative program, should be subjected to arthrodesing operations or to other orthopaedic surgical procedures. In all of the fifteen cases included in this table the patients complained of low-back pain, or of sciatica, or of a combination of the two. Most of these cases had been previously diagnosed as chronic low-back strain or arthritis, and, in several instances, the patients had been treated by plaster-cast immobilization, braces, or physical-therapy

TABLE II

Low-Back Pain Caused by Neurological Lesions

Case		Age (Years)	Sex	Symptoms	Diagnosis *
1.	E. C.	54	Female	Low-back pain	Fibrochondroma of cauda equina
2.	Y. C.	47	Male	Low-back pain, sciatica, and weakness of legs	Fibrochondroma of cauda equina
3.	H. S.	47	Male	Low-back pain and sciatica	Intraspinal chondroma of intervertebral disc
4.	J. W.	54	Male	Pain in lumbar region and in right leg	Tumor of cauda equina
5.	D. G.	30	Male	Pain in low back and in both legs	Giant-cell tumor of twelfth thoracic and first and second lumbar vertebrae
6.	B. L.	58	Male	Low-back pain and difficulty in walking	Hemangioma of epidural space
7.	E. T.	45	Female	Pain in thigh and later in low back	Tumor of cord at eighth, ninth, and tenth thoracic vertebrae
8.	L. S.	49	Male	Pain in back and in legs	Capillary hemangioma of cauda equina
9.	P. K.	54	Male	Low-back pain and bilateral sciatica	Tumor of filum terminale
10.	K. S.		Female	Severe low-back and abdominal pain	Neurofibroma of eleventh thoracic segment
11.	R. B.	2½	Male	Pain in leg, limp, and weakness	Giant-cell tumor of conus medullaris and of cauda equina
12.	D. W.	3	Male	Pain in both legs	Intramedullary dermoid cyst
13.	F. K.	47	Female	Pain in back and in legs of 6 years' duration	Cystic neurofibroma of tenth to twelfth thoracic vertebrae
14.	K. B.	23	Female	Pain in sacro-iliac region and down both legs	Extradural fibroma of fifth lumbar vertebra
15.	B. K.	22	Female	Pain in groin and in low back, numbness in leg	Extradural cyst at lumbosacral level

*Diagnosis made or confirmed by operation.

exercises over a period of months or of years. Fourteen of the fifteen patients were improved or relieved of their symptoms following operation by one of the neurosurgeons of the University of Chicago Clinics.

Case 15 is deserving of some further comment.

This patient, B. K., female, aged twenty-two years, entered with the complaint of low-back pain of several years' duration. She also complained of pain in the right lower quadrant of the abdomen, for which an appendectomy had been performed without relief, pain in the hip, and pain in the urinary bladder when she voided. There was a history of intermittent attacks of nausea, vomiting, and headaches. The first impression was that she was suffering from a rather marked psychoneurosis. A roentgenographic examination, however, showed congenital anomalies of the lumbosacral region and definite scoliosis with lateral wedging of the lower lumbar vertebrae. (See Figure 1.) Cystoscopic studies revealed a cord bladder. An operation was performed with the intention of arthrodesing the lower lumbar spine with the sacrum. The posterior bony wall of the

sacral canal was found to be almost paper-thin, and, when it was opened, a large, bluish, fluid-filled sac bulged through the defect. When the sacral canal was further explored, it was found to be markedly enlarged, and an extradural cyst, which extended from the upper level of the fourth lumbar vertebra to the lower level of the third sacral vertebra, was removed. Little benefit was derived from the operation. The neurological findings have persisted, and the patient continues to complain of the pain previously described, although the spine was fused following excision of the cyst.

FIG. 1

Case 15. B. K. This patient had multiple developmental anomalies of the lower lumbar spine, partial saddle anaesthesia, and pain in the low back and urinary bladder. A large extradural cyst, extending from the third lumbar vertebra to the third sacral vertebra, was removed at operation, and the fourth and fifth lumbar vertebrae were fused to the sacrum.

Four patients who presented themselves because of low-back pain had been under treatment because of a diagnosis of chronic arthritis or of strain. In each of these cases, further examination revealed a neoplastic lesion in the region of the sacro-iliac joint. Three of the lesions were undifferentiated round-cell sarcomata and one proved to be a chondrosarcoma. Final diagnosis was made in each case by biopsy and partial excision. The following case is typical of the patients in this group.

J. A., a female, aged twenty-five years, came to the University of Chicago Clinics because of pain in the back and right-sided sciatic neuritis of two years' duration. Prior to being seen by the orthopaedic consultant, a diagnosis of arthritis was made and the patient was subjected to tonsillectomy and extraction of two teeth. Orthopaedic examination revealed a firm palpable tumor over the left sacro-iliac region, and a roentgenogram showed an area of bone destruction on the left side of the sacrum, extending across the joint and involving a small area in the left ilium. (See Figure 2.) Biopsy showed gross tumor tissue in the sacrum, in the sacro-iliac joint, and in the ilium. The microscopic diagnosis was undifferentiated round-cell sarcoma. This patient was treated intensively with x-ray, and, although left sciatic-nerve paralysis developed, she was alive and showed no evidence of metastasis two years after initiation of therapy.

The following report illustrates still another variation.

I. W., a female, aged thirty-seven years, was admitted to the University of Chicago Clinics because of pain in the back at the lumbosacral level. There was no sciatic

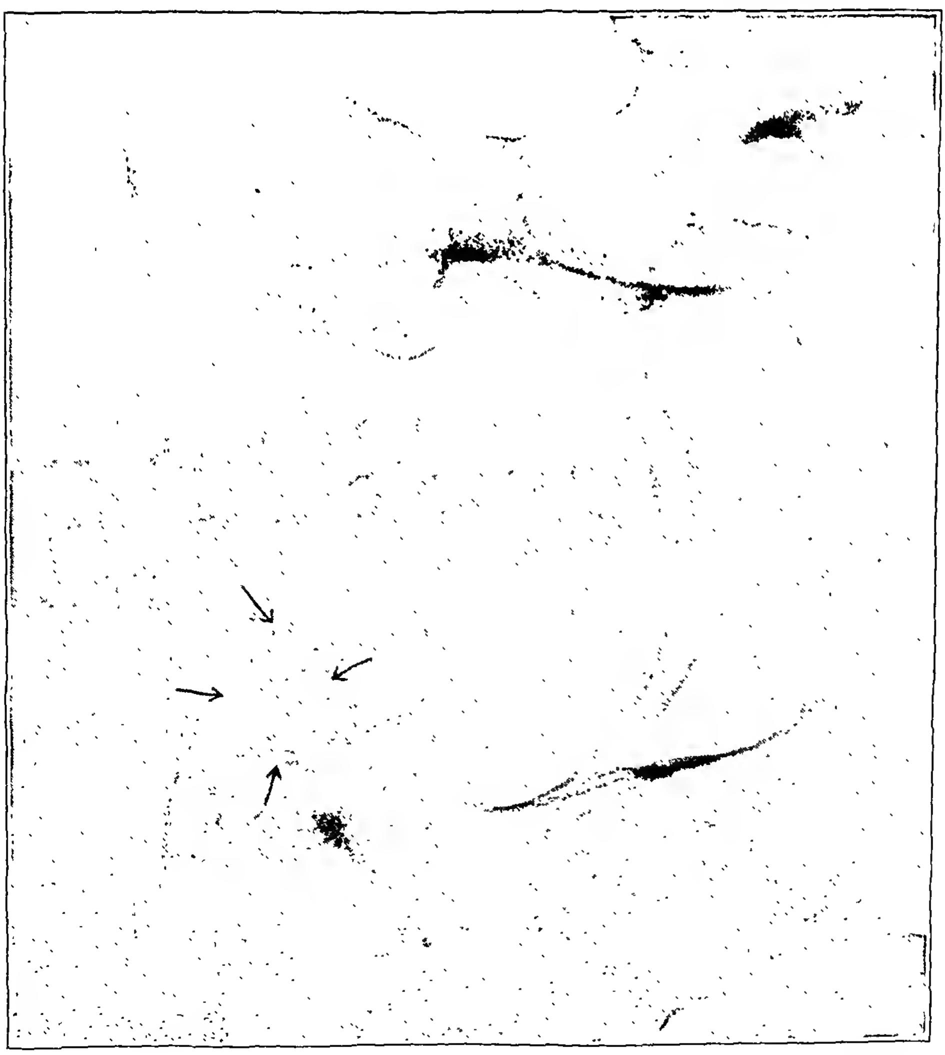

FIG. 2

J. A. This patient was treated for supposed arthritis. A tonsillectomy was done and two teeth were extracted. The roentgenogram shows a lytic lesion in the left wing of the sacrum with extension into the adjacent portion of the ilium. Microscopic diagnosis of tissue from this area was "undifferentiated round-cell sarcoma".

FIG. 3

I. W. This was a case of chronic lumbosacral strain. The disability markedly increased after lipiodol injection. Complete recovery followed laminectomy, partial excision of lipiodol material, and lumbosacral arthrodesis.

neuritis. This patient had been examined in several other clinics and a diagnosis of chronic low-back strain had been made. Two years prior to her admission to the University of Chicago Clinics, five cubic centimeters of lipiodol had been injected into the spinal canal. This revealed no block and the lipiodol was not removed. In spite of the fact that the patient had been given spine braces and physical therapy, she stated that the back pain had become very much more marked following this injection. She described a sensation of weight or of pressure at the level of the first or second sacral vertebra. Our roentgenograms showed a large amount of lipiodol streaked throughout the lumbar portion of the spinal canal and a mass of this material, one and five-tenths centimeters in diameter, at the lumbosacral joint, with additional amounts as low as the second sacral vertebra. A lumbosacral arthrodesis was advised and during this operation the sacral canal was opened and a mass of encysted lipiodol material was removed. The roentgenogram (Fig. 3) shows the condition following operation. Lumbosacral fusion has been successful. There is a space, one centimeter in diameter, from which most of the lipiodol has been removed, but considerable amounts of this material are still present. The patient is clinically free from symptoms.

Based on these experiences, the author would be inclined to list the following contra-indications to low-back fusion operations:

1. Infectious or multiple arthritis.
2. Compensation cases before financial settlement.
3. Elderly or poor-risk patients.
4. Female patients before puberty.
5. Any patient without definite evidence of osseous deformity or disease until conservative measures—including the Goldthwait or Williams program, manipulation and cast, or the Ober operation—have been given a thorough trial.

It is the author's impression that, after ruling out primary neurological lesions, infectious arthritis, primary bone tumors of the pelvis, and various types of neuroses, in addition to giving the patient the benefit of a conservative program over a sufficiently long test period, the operation of choice for chronic low-back pain is arthrodesis of the joints in which the lesion can be localized. He has not had sufficient experience with the operations described by Ober, Heyman, or Freiberg to discuss their merits or indications. It is the opinion of the author that in most cases the tight iliotibial band can be relaxed by the Goldthwait-Williams type of exercises.

Sashin and Willis have each reported studies showing that degenerative changes, probably due to constant or to repeated strains and pressure effects upon the articular surfaces, result in many instances in osteo-arthritic spondylitis which may lead in a considerable number of cases to eventual bony ankylosis of the sacro-iliac joints. Of 1,559 human skeletons studied by Willis, ninety-six were completely ankylosed. Willis concludes: "From the standpoint of skeletal change the sacro-iliac joint is more frequently and more extensively involved in arthritic lesions than any other joint of the body. . . . Since the joint retains in man the anatomical features of its quadrupedal origin the mechanical stresses peculiar to the upright posture subject it to ligamentous strains. Ankylosis is a compensatory mechanism for stabilization." Sashin's conclusions are in agreement.

It is the author's custom to manipulate under anaesthesia, stretching the tensor fasciae femoris and the hip flexors in an attempt to flatten the lumbosacral spine preliminary to fusion. The spine is then fused, maintaining as nearly a normal lumbosacral curve as possible. At the time of lumbosacral fusion, the articular facets are excised and additional bone, either from the ilium or from the tibia, is used to produce a more satisfactory bone splint.

The author has purposely excluded from the list of operations the excision of portions of the intervertebral discs which may have protruded into the spinal canal. This is primarily a neurosurgical procedure. Two such operations have been reported from the University of Chicago Clinics (*Bucy*). Unless the annulus fibrosus has been injured posteriorly, so that nucleus-pulposus material has escaped into the spinal canal, forming cartilage-like bodies, a correction of the body posture by the Goldthwait-Williams exercises should lead to tightening up of these posterior fibers of the annulus fibrosus and restoration of the contour of the intervertebral disc. Possibly some of the patients subjected to laminectomy operations for excision of these discs could have been relieved by this more conservative program.

Surgical arthrodesis of the lumbosacral and sacro-iliac joints is indicated in cases of chronic low-back pain due to:

1. Spondylolisthesis.
2. Spondylosis (solution of bony continuity of the isthmus or pars interarticularis of the neural arch without displacement).
3. Tuberculosis of the lumbosacral or sacro-iliac joints.
4. Localized degenerative arthritis and loss of the lumbosacral intervertebral space.
5. Persistent disabling low-back pain, with or without congenital anomalies, which cannot be relieved by more conservative procedures.
6. Chronic pain following fractures or fracture-dislocations of the lumbosacral or sacro-iliac joints.
7. Chronic sclerosing osteitis involving these joints.

CONCLUSIONS

1. The vast majority of cases of low-back pain can be relieved and the patient restored to functional usefulness without operative interference.
2. Correction of bad body mechanics by physical therapy, including stretching of contracted fascia or muscles, exercises, and the use of a good spine brace over a period of time, will restore the average patient to a reasonable degree of normalcy.
3. Orthopaedic operations for the relief of low-back pain should be performed only after diagnosis has been accurately established and osseous neoplasms or neurological lesions have been excluded.

4. Pathology of the low-back region which may call for operative interference includes tuberculosis or chronic sclerosing osteomyelitis of the lumbosacral or sacro-iliac joints, primary malignant neoplasms, lesions of the spinal cord, spondylolysis, and spondylolisthesis.

5. Arthrodesing operations are contra-indicated if there is evidence of chronic infectious arthritis of the spine or of other joints.

6. Patients with a psychiatrie background, who show no definite pathology in the low-back region, are considered to be poor selections for operation.

7. Patients who are seeking financial settlement because of a compensable injury are not suitable for spinal-fusion operations until after financial settlement has been made, unless there are definite osseous changes which can be demonstrated.

8. In patients for whom arthrodesing operations are planned it should be possible to localize the lesion to the joint affected. Trisacral fusions are probably rarely indicated. Multiple-joint-fusion operations are often merely shot-gun procedures.

9. Operation may be justifiably recommended for the patient with chronic low-back strain, without definite roentgenographic evidence of local pathology, which cannot be relieved by the conservative program so that the patient can resume a reasonable degree of activity, and, particularly, for patients whose economic status requires that they do manual labor in order to earn a living.

10. In the author's opinion, an arthrodesing operation is the procedure of choice.

11. The operation itself is preceded by vigorous stretching and manipulation. It is further recommended that, in fusing the spine, care be taken that the normal lumbar curve be preserved.

12. If there is a sciatic neuritis, the surgeon should excise the articular facets on both sides between the fourth and fifth lumbar vertebrae and the fifth lumbar vertebra and sacrum.

13. The orthopaedic surgeon must be constantly alert to the fact that neurological lesions or primary osseous neoplasms may produce symptoms of low-back pain and sciatic neuritis.

14. The judgment and skill of the orthopaedic surgeon may be measured by his ability to select, from the great numbers of patients who consult him because of symptoms of low-back pain, those with real indications for operative treatment. His courage may be shown either in refusing to perform an operation when it is urged that he do so and his conscience and judgment say "no", or in his determination to operate when he is convinced that only by such a procedure can the patient be cured.

15. In his own practice the author fears that he has been overconservative at times and guilty of the sin of surgical omission. And yet, in so short a series as that presented here, at least five operations have been performed which subsequently have been the cause of regret.

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OPERATIVE TREATMENT OF COCCYGODYNIA *

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The most important lesion of the coccyx is that which is usually termed *coccygodynia*, or painful coccyx. This is a condition which occurs predominantly in women, but it may occur in men. The majority of the cases are due to a definite injury, such as a fall directly on the sacrococcygeal region or a kick or blow in this region, or to some injury which occurs during labor. Occasionally the condition appears gradually and without known cause. There are, in the main, two groups of opinions as to the etiology. One group, composed largely of neurologists, believe that the condition is entirely a functional neurosis and that treatment directed at the coccyx does little or no good. The other group, composed largely of surgeons, believe that the condition is due to some pathological lesion in the coccyx, or in the coccygeal plexus of nerves which surround it, and that treatment of the coccyx should be instituted in an effort to relieve the pain. This paper is based on a series of fifteen cases of coccygodynia in which I have operated and in fourteen of which it has been possible to ascertain the result.

The symptoms vary from slight pain in the coccyx after prolonged sitting to excruciating pain and tenderness which may make sitting almost intolerable, and they are not infrequently accompanied by nervousness and irritability which cause the patients to be considered psychoneurotic. The most important symptoms are: (1) pain on sitting, which is usually more marked when sitting in a soft chair, although some patients complain of more pain when sitting on a hard chair, and all patients complain that after sitting for some time, as in a theater, the pain is aggravated; (2) a rather sharp pain on getting up from a chair or on sitting down; (3) pain on defecation; (4) pain on stooping; (5) pain on lying on the back; and (6) pain on walking. The pain is always localized in the midline at the tip of the spine, but may be referred either to the right or to the left buttock and for this reason may resemble a sacro-iliac lesion. It is caused by pressure on the coccyx or by strain on the muscles attached to the coccyx.

On physical examination, there is acute pain on direct pressure over the coccyx. There is also pain on pressure on its anterior or deep surface by rectal examination and pain on manipulation of the coccyx with the finger in the rectum. A roentgenographic examination may or may not reveal a deformity. In some of my patients the x-ray has shown the tip of the coccyx to be bent forward or deviated laterally, and in one instance

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the tip was so flexed that it pointed directly upward. In none of the patients operated upon has the roentgenogram revealed a fracture or a dislocation. At the present time I do not consider the x-ray an aid in the diagnosis of coccygodynia, except to rule out possible disease. The diagnosis is made from the history and the presence of acute tenderness when pressure is made over the coccyx. As a matter of fact, even a rectal examination is not necessary for the diagnosis, although it is usually done, presumably to rule out hemorrhoidal pain. However, I see no reason why pain due to hemorrhoids should be confused with tenderness of the coccyx.

PATHOLOGY

I have not been able to find in the literature anything concerning the pathology of coccygodynia, other than the occasional statement that the coccyx was bent or deformed or fractured. In my opinion, the gross form or position of the coccyx has little or nothing to do with the syndrome of coccygodynia, because no two coccyges which I have removed were alike and most of them would be classed as normal.

In attempting to explain the condition, I have sectioned six of the specimens and studied them microscopically, but the sections revealed apparently normal bone and connective tissue and showed no evidence of arthritis or of inflammation. The pathology is, then, unknown.

TREATMENT

In acute coccygodynia there is usually a history of a recent injury to the coccyx and the patient is suffering considerable pain and desires relief. When possible, a roentgenogram should be obtained in order to determine whether or not a fracture or displacement of the coccyx is present. If there is a definite dislocation or a fracture with marked displacement of the fragments, an attempt should be made to reduce the displacement, and local or general anaesthesia may be used. The coccyx is easily grasped between the finger in the rectum and the thumb on its posterior surface and may be manipulated as desired.

However, dislocations are very rare and in fractures there is usually little or no displacement of the fragments. In fractures without displacement the treatment is the same as though no fracture were present. Sedatives are given when necessary and a hot sitz bath is prescribed to relieve the pain. The patient is advised to get an inflated rubber ring or a horseshoe-shaped cushion to sit on and to avoid movements or positions which aggravate the pain. Strapping the low back and buttocks with adhesive may be tried, but, if this causes the pain to be more severe, the adhesive should be removed. The same is true of a girdle. In some cases a girdle or corset gives some relief, but in others it causes the pain to be more severe. If the pain is very severe, the patient should be advised to remain in bed for a few days or until she can be up and about with comparative comfort.

A coccygodynia may be said to be chronic when the pain has persisted over a period of two months or more. It is the chronic coccygodynia with which this paper is especially concerned. At present there is wide divergence of opinion concerning the best form of treatment for this condition.

Many patients with a chronic coccygodynia are quite nervous or definitely psychoneurotic, and many believe that coccygodynia is a functional disorder and that treatment directed at the coccyx is unwise. A certain percentage of these patients get well under psychotherapy if it can be continued long enough. The same is true of any other form of therapy, or of no therapy. In many patients the pain eventually disappears, but it may recur.

For chronic coccygodynia, Baastrup recommends deep x-ray therapy and states that ten out of fifteen patients were cured by this treatment. Injections of alcohol into the painful area have been used for thirty years and are still recommended (Yeomans), but they have not gained popular favor and Gant definitely states that in his hands the injection treatment was not successful. Kleckner injects 5-per-cent. quinine and urea hydrochloride, and Mandl uses forty cubic centimeters of .5-per-cent. novocain. Recently Suermondt has injected forty cubic centimeters of 1-per-cent. novocain into the sacral canal and the injection is repeated at intervals if necessary.

When consulted by a patient with chronic coccygodynia, I am interested in the course and severity of the pain and the patient's reaction to it. If the pain is not very severe or is becoming less severe and if it does not greatly inconvenience the patient, I give her a mild sedative or small doses of salicylates, have her get an inflated rubber ring to sit upon, advise her to avoid, if possible, movements or positions which aggravate the pain, and tell her that, if the pain should become sufficiently troublesome to warrant an operation, the coccyx can be removed with the expectation that the pain will be relieved permanently. However, most of these patients never come to operation.

If the pain is severe and causes great inconvenience to the patient, I try the line of treatment just described for a few weeks and, if there is no improvement, advise removal of the coccyx. The operation may be fairly difficult and I think that it should be performed with meticulous care.

TECHNIQUE OF THE OPERATION

The patient enters the hospital on the day preceding the operation and is started on a low-residue diet.

The operation is performed under general anaesthesia with the patient prone upon a table, one end of which may be lowered so that the thighs may be flexed about 30 degrees.

I have not tried the transverse incision; I use a midline vertical incision about two and one-half inches long, the middle of the incision being

over the sacrococcygeal articulation and the lower end well removed from the anus. This incision is carried down to the bone throughout its length, and it is usual to find the coccyx pointing directly downward,—that is, away from the skin incision. By sharp dissection, as much as possible of the posterior surface of the coccyx is exposed. If it is bent forward, the tip cannot be exposed until later.

After the posterior surface of the coccyx has been well exposed, the posterior part of the intervertebral disc between the coccyx and the sacrum is cut with a knife. The ligaments between the inferior part of the sacrum and the first segment of the coccyx are then carefully cut away from the coccyx; in so doing the operator should keep close to the bone. Usually at this point a small artery is cut on each side of the bone and this must be clamped in order to secure a clear field.

After the lateral part of the first segment is freed, it is grasped with a towel clip and, by twisting it from side to side, the remaining attachments to the sacrum are put on tension and cut with a knife. The coccyx is then pulled gently backward—that is, in the direction tending to pull it out of the wound—and, by sharp dissection with a knife, the aponeurotic fibers are cut from its lateral borders and the tissues are cut from its deep surface. This dissection is done a little at a time, first on one side and then on the other. It is to be remembered that the rectum lies very close to the deep surface of the coccyx and for this reason the knife is kept against the bone. Some surgeons have an assistant keep his finger in the rectum during this part of the operation. I cannot see what good this does, and I should be afraid that the assistant might push the wall of the rectum backward and endanger both the rectum and his finger. When the tip is reached, the strong fibers attached to it are cut transversely and the entire bone is removed in one piece. On three occasions, where the tip has been curved forward, I have severed the coccyx near its end and have then removed the tip separately. This was done accidentally, but it is the easiest and safest way to remove a tip which is anteverted.

After the coccyx has been removed, the distal end of the sacrum is found to be quite prominent. This prominence is removed by beveling the posterior margin of the lower end of the sacrum or, if necessary, by removing some of the entire thickness of the bone and beveling what is left, the object being to leave nothing that will be irritated by pressure from without.

An effort is then made to restore the posterior pelvic floor by placing from two to four mattress sutures of chromic catgut in the aponeurotic tissues which have been cut from the margins of the coccyx and drawing them together in the midline to obliterate the dead space and to cover the stump of the sacrum. The subcutaneous tissues are then closed snugly with No. 000 plain catgut, the skin is closed with silk, and a small dry dressing is applied.

The dressing is not sealed with collodion nor is the buttock strapped, but the nurse is cautioned to watch the patient and to change the dressing

if it should become soiled. The constipating diet is continued and on the fourth day the patient is given an enema, after which the dressing is changed. The sutures are removed on the fifth or sixth day and the dressing is kept on about a week longer.

Most of the patients leave the hospital in six or seven days and begin to walk a little. Their activity increases as the wound heals firmly, and there is no after-treatment.

An immediate cessation of pain is not to be expected, because the painful coccyx has been replaced by a fresh operative wound. The average patient is quite active within three or four weeks after the operation, but still has some pain on sitting. This usually disappears within a month or two, but in an occasional case it is three or four months before the patient can attend a theater with comfort.

CLINICAL RESULTS

During the past six years I have operated upon fifteen patients, using the technique described. There were fourteen women and one man in the series and their ages ranged from seventeen to fifty-eight years. Eleven of these patients attributed their condition to a fall on the end of the spine or tail bone; one patient was kicked; one, who was a stenographer, believed that her symptoms were due to sitting all day in an uncomfortable office chair; and in two cases the symptoms appeared after normal deliveries. The symptoms had been present for from three months to twelve years and the average duration of symptoms was a little over two years.

As to the results of the operation, it has been possible to trace fourteen of these patients and all except two have been completely relieved of their coccygeal symptoms. One of these was operated upon only one month prior to this report, at which time she was convalescing normally with the expectation of obtaining complete relief within another month or so. The other is a woman, fifty-eight years of age, who was operated upon five months before this report and whom I have not seen since she left the hospital eight days after the operation. She writes that her symptoms, which were quite severe, have almost entirely disappeared, but that she still has a little pain after sitting for a long time in one position.

I have not been able to trace one of the clinic patients. She was from out of town and was operated upon in 1933. Six months after the operation her husband wrote that she was worse than before the operation, but, as she also complained of pain in the right lower quadrant of the abdomen before the operation, I do not know whether her later symptoms were due to this or to the coccyx, and repeated letters have not been answered.

Two of the patients have borne one or more children since the operation and have had no difficulty.

One patient also complained of severe pain and tenderness over the first and second sacral spinous processes. Therefore, the incision was

extended upward and those spinous processes were removed with subsequent disappearance of the pain.

There were two postoperative complications. One patient began to menstruate on the day after the operation and the skin wound became red and inflamed. Two days later, I removed the sutures and the skin edges separated. The wound took about a month to heal. Now I do not operate on the coccyx during the week before a menstrual period is expected.

The other complication was due to poor surgical judgment. Seventeen days after the coccyx was removed, a large Bartholin-gland cyst was excised by a gynecologist. Six days later, the coccygeal wound was opened and a considerable amount of pus was evacuated. Later a rectal fistula developed and of course I was accused of having nicked the rectum. However, the coccygeal wound healed and, when the rectal fistula was excised some months later, the tract led to the labia and there was no tract to the sacrococcygeal region, so I was exonerated.

CONCLUSIONS

1. Most cases of acute and of mild chronic coccygodynia respond to conservative treatment.
2. In severe chronic coccygodynia, excision of the coccyx, followed by careful restoration of the pelvic floor, may be expected to relieve the symptoms and to cause no disability.

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RESULTS OF FASCIOTOMY FOR THE RELIEF OF SCIATIC PAIN † *

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This report is concerned with an analysis of the results of division of the fascia lata for the relief of sciatic pain in forty-nine patients who were operated upon at the New York Orthopaedic Dispensary and Hospital between June 1, 1932 and February 10, 1936. In ten cases, the operation was done on both sides, and in two it was repeated on the same side because the first procedure apparently was incomplete, making in all sixty-one operations on fifty-nine extremities. The technique in all cases was that described by Ober. Twenty-three patients were males and twenty-six were females. The average age of the group was thirty-seven years, and the average period for which they were observed after operation was sixteen months. In only nine cases was the follow-up less than one year, and the majority of these were failures, in which the results would not have been influenced by longer observation.

The patients all had pain of a similar distribution, starting in the sacro-iliac region or buttock and radiating down the posterior aspect of the thigh. In many it continued along the outer side of the leg to the ankle. Several stated that the pain was present in the posterior gluteal region and that it skipped the thigh, appearing again in the leg. In all instances it was severe. Although pain of this character usually is called sciatica, it should be realized that this name applies to a symptom only, which may be due to a number of different causes, and that it does not necessarily imply an inflammation of the sciatic nerve.

In addition to having sciatic pain, these patients also exhibited a tightness of the fascia lata and iliotibial band. This was demonstrated by the Ober test, in which the patient is placed on his side with the hip and knee flexed. The uppermost extremity is then extended and abducted with the knee flexed, and then allowed to adduct in the extended position. If the fascia is taut, adduction is limited and the fascia stands out as a definite band. In the majority of cases, flexion of the hip with the knee extended was limited and painful. In a few cases, hyperextension of the thigh also was limited. The interesting observation was made that in several patients the Ober test varied from one day to another. It is believed that in these cases the tightness of the fascia was due to muscle contraction. Real structural contracture probably is a later occurrence, after the muscles have been in spasm for a long time.

† Read before the Neurological and Orthopaedic Sections of the New York Academy of Medicine, New York City, February 11, 1936.

* Read by title at the Annual Meeting of the American Academy of Orthopaedic Surgeons, Cleveland, Ohio, January 14, 1937.

The mechanism by which a taut or contracted fascia lata causes sciatica has not been satisfactorily explained. It is true that in many individuals who have not had pain the Ober test is positive. Nor has any explanation been given for the fact that patients with a markedly contracted fascia lata, resulting from paralysis in poliomyelitis, do not have pain.

Backache was also present at some time in most of these patients. By this is meant pain extending across the whole lumbosacral region in contradistinction to the pain on one side, which is a part of the sciatica. As a rule, the low-back pain preceded the sciatica and often disappeared when the latter began.

It is of the greatest importance in all cases of sciatic pain to do a careful neurological examination in order to rule out the presence of a spinal-cord tumor or possibly a protruding nucleus pulposus. Such an examination was made in all of these patients by a competent neurologist, usually without significant findings. One man had no patellar reflexes and several patients had absent or diminished ankle jerks. In a few there was slight hypaesthesia over the outer side of the leg. A spinal puncture was done in a number of cases, with normal results. However, in one patient, seen after this series was concluded, a high total protein in the spinal fluid was the means of discovering a cholesteatoma of the spinal cord. One patient in this group, after a thorough examination at a neurological hospital, was said to have a chronic meningomyelitis, in spite of which her sciatic pain was cured by fasciotomy.

Lumbosacral roentgenograms were taken of all the patients and, with one or two exceptions, they revealed variations in the lumbosacral joints which might be supposed to cause instability and to predispose to pain. These variations included exaggerated lumbosacral angle, anteroposterior or asymmetrical articulations, posterior displacement of the fifth lumbar vertebra, transitional lumbosacral vertebra, and thin intervertebral disc. Several patients had evidences of arthritis in the lumbosacral spine.

The operation was performed through an almost transverse incision from below the anterior superior iliac spine to a point behind and above the greater trochanter. The fascia lata was thoroughly sectioned, including the septa between the muscles. The patients were allowed up in from seven to ten days.

Because of certain other operations which were done on some of the patients, it is necessary to divide them into three groups for purposes of analysis: (1) those on whom a fasciotomy alone was performed; (2) those who previously had had a fusion of the lumbosacral spine and who then had a fasciotomy for continued sciatica; and (3) those on whom some other operation, usually a spine fusion, was done at or about the same time as the fasciotomy.

Group I—Fasciotomy Alone

There were twenty patients in this division. The average age was forty years, and they were about equally divided as to sex. The sciatica

was unilateral in nineteen and bilateral in one, and had been present from four weeks to eighteen years before operation; in eleven cases it was of more than one year's duration. Twenty-one operations were performed. Complete relief of sciatica followed the operation in thirteen patients. Two complained of slight pain afterward and five obtained little or no relief. Seven patients had no backache either before or after the operation. Five had back pain before operation, which continued afterward, and four others were relieved of backache by the operation. However, in four patients who had had no back pain before the operation, pain developed after fasciotomy. The results of fasciotomy, considered from the standpoint of sciatica alone, were classed as excellent in nine, good in six, and unsatisfactory in five. It is interesting that in one patient who obtained complete relief from a severe left sciatica in October 1935, right sciatica developed in November 1936, which was also immediately and completely relieved by fasciotomy.

In examining the five cases with poor results, it was found that in one case, that of a physician, thirty years of age, there was not only failure to obtain relief from the sciatica, but also a return of the back pain. This patient had a posterior displacement of the fifth lumbar vertebra, and both the sciatica and the back pain were cured later by a spine fusion. In another patient with a posterior displacement of the fifth lumbar vertebra, there was diminution of the sciatic pain (which he estimated to be 75 per cent.) for several months, but then both the back pain and the sciatica returned. A third was a compensation case and the patient refused to return to the Clinic. Two patients were seventy-five and eighty years of age respectively. Both had arthritis and probably were not good subjects for the procedure.

Group II—Spine Fusion Followed Later by Fasciotomy

Twenty patients were included in this group, whose average age was thirty-three and five-tenths years. There were twelve unilateral and eight bilateral operations. The procedure was repeated in one case. These patients presented, on the whole, a more severe type of lumbosacral abnormality, and eighteen had more or less severe back pain in addition to the sciatica. As a result of the spine fusion, the back pain was relieved in seven cases, but the sciatica continued in all. Before the fasciotomy was performed, the sciatica had been present for from three months to sixteen years, and in sixteen patients, for more than one year. At the time of the last examination, which averaged seventeen months after operation, the sciatica still was severe in fifteen, slight in one, and absent in four. Back pain still was present in eleven. The results were excellent in four, good in one, and unsatisfactory in fifteen.

Among the fifteen failures, there were two cases of pseudarthrosis, or imperfect spine fusion, which probably accounted for the sciatica. Ten of these patients obtained partial or complete relief, lasting from two to sixteen months. The standard by which these cases are judged as failures,

therefore, is a severe one. It is believed that in these cases such a simple operation was worth while, even though the relief from pain was not permanent. This group also emphasizes the importance of a long follow-up study of this condition. It is difficult to decide whether the relief from back pain in some of these cases was due to the spine fusion or to the fasciotomy, in spite of the fact that in the majority an appreciable interval occurred between the two.

Group III—Fasciotomy Combined with Another Operation

Very little can be learned about the effect of fasciotomy in the nine patients who comprised this group, because of the fact that a spine fusion was performed either at or about the same time in eight cases, and a sacro-iliac fusion was done in one. The average age was thirty-five. There were six females and three males, and the sciatica was unilateral in eight and bilateral in one. Nine operations were performed. Five patients had back pain in addition to sciatica before operation. Six patients obtained complete relief from sciatica; one continued to have slight pain; and two still had severe pain after operation. Back pain was severe in three, slight in one, and absent in five following the operative procedures. One failure was attributable to infection and consequent failure of the spine-fusion operation. It is probable that in two cases the fasciotomy would have been a failure, because the sciatica continued after it was done, and disappeared after a spine fusion a short time later.

In all of the groups, relief from the sciatic pain usually was prompt and often dramatic in its suddenness. In few cases was the improvement gradual. A study of the effect of the operation on back pain, as distinguished from sciatica, shows that in twelve patients, who had such pain previously, there was none after operation; in twenty no relief from back pain was obtained; and in four, who had no back pain before fasciotomy, it developed afterward. Furthermore, it is quite probable that the relief from back pain obtained in some of the twelve cases was attributable to a spine fusion rather than to the fasciotomy.

Search has been made for some common factors in the successful results which would give us a clue in selecting those patients most likely to be benefited by this procedure, but none, other than the taut fascia lata, has been found. It would seem that in cases of severe backache and sciatica with pronounced lumbosacral abnormalities, as well as in cases of advanced arthritis, good results are least likely to be obtained, but to this there are several notable exceptions. There was no significant difference in the duration of the pain between the successful cases and the failures. That the operation is of great value in certain cases is unquestionably true. Further study of this problem should help us to determine in advance which cases are suitable.

SUMMARY

The results of fasciotomy performed on forty-nine patients with

sciatic pain, whose average postoperative observation period was sixteen months, were as follows:

1. In the group who had a fasciotomy only, excellent or good results were obtained in 75 per cent.; failure resulted in 25 per cent.

2. Of twenty cases in which lumbosacral fusion had failed to cure the sciatica, subsequent fasciotomy resulted in failure in 75 per cent. However, many of these patients obtained temporary relief of from two to sixteen months.

CONCLUSIONS

1. Fasciotomy cannot be relied upon to cure low-back pain as distinguished from sciatica.

2. Although the mechanism by which fasciotomy cures sciatica is not known, the operation has proved of value and further study should throw more light on the selection of suitable cases.

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THE MECHANICS OF THE LUMBOSACRAL AND SACRO-ILIAC JOINTS *

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The fundamental principle of the orthopaedic surgeon, whether he is working on joints or fractures, is the prevention of deformities, and his aim is the attainment of the optimum position for function. The optimum position for function is entirely dependent on the shape and range of motion of the joints in question and on the shape and position of the adjacent joints. For example, the best position for arthrodesis of a tuberculous knee with a normal hip joint above it is entirely different from that required if the hip has limited motion. The optimum position for an arthrodesed hip is dependent on the amount of compensatory motion in the spine. Likewise the optimum position for function of one part of the spine is equally dependent on the position and condition of the rest of the spine. The enormous compensatory mechanism of the spine as a whole has dimmed the importance of the position of one section of the spine in its relation to the other parts.

FIG. 1

Lateral views of three sacra, showing the variety in the size and shape of the sacro-iliac joints. All the joints are roughly auricular in shape,—broadest in the upper part, narrowest in the middle portion, and widening slightly in the lower part. In the upper part the width of the joint is about one-half and in the lower part about one-third, or less, as large as the longest diameter.

Willis and many others have pointed out the many anatomical variations in the different sections of the spine and it is not necessary to mention these, except to point out that, since no two spines are anatomically alike, each one must be judged on its own individual structure.

Whatever the anatomical shape of the bones may be, there is always an optimum position for function for that particular anatomical variety of spine, and that position is the one in which none of the spinal joints are either at the point of extreme flexion or of extreme extension. The range of motion from this optimum position is entirely dependent on the anatomical structure of the bones. If, for a period of years, the habitual

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position of use of the lumbar spine has been that of extreme extension—a position which is so common in the growing period of life—there will be, according to Wolff's law, changes in the shape of the bones as well as in the ligaments and muscles which are attached to the pelvis and the hip joints. A method of treatment, therefore, which corrects only one deformity and leaves the rest of the spine uncorrected is not following out the orthopaedic and surgical principles which should be the basis of all of our work.

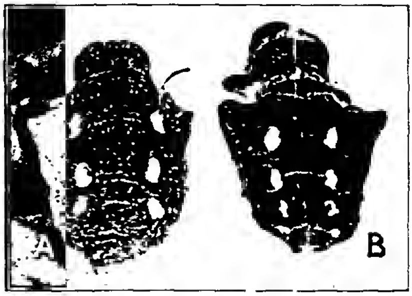

FIG. 2

Photograph of sacra from the anterior surface. Sacrum *A* is roughly rectangular and sacrum *B* is more triangular. In the latter, the width between the wings or the upper part of the sacrum, on the external side of which are the sacro-iliac joints, is much more than that in the middle of the body of the sacrum. As a result, the sacro-iliac joints are in an oblique plane. In the former, the width between the wings and that in the middle of the sacrum is about the same. This means that in this type of sacrum the sacro-iliac joints are nearly vertical and are consequently more unstable.

As has been stated, there can be no degree of curve that is the correct one for all spines and also the curve of any one part of the spine is greatly affected by the curves of the other parts of the spine. It is a simple matter to teach an individual to flatten the curve of the lumbar spine, but there may be little or no difference in the strain on the lumbar region if the thoracic and cervical curves are not corrected at the same time. Flattening the lumbar spine is always accomplished by changing the inclination of the pelvis. Since a change in the inclination of the pelvis affects the mechanics of the sacro-iliac joints, it is well to consider the mechanics of these joints at this point.

The sacrum has always been considered as an inverted keystone to the pelvic arch. The sacro-iliac joints are described as auricular-shaped, broadest in the upper part, narrowest in the middle, and widening slightly in the lower part. (See Figure 1.) The longest diameter of the joint surfaces is parallel to the body of the sacrum. The shortest is from the anterior to the posterior surface of the sacrum. At the upper end of the sacrum the shortest diameter of the joint is about one-half as long as the longest diameter, while in the middle of the joint it is one-third or less. The surfaces of these joints are covered with articular cartilage, and there are small prominences and hollows which articulate with hollows and prominences in the opposing joint surfaces of the ilia.

Sacra viewed from the front show considerable variations in shape. Some are roughly rectangular (Fig. 2, *A*) and others are more triangular (Fig. 2, *B*). In the latter the wings of the sacrum, on the external side of which are the sacro-iliac joints, are wider than the lower part and, as a result, the sacro-iliac joints are in an oblique plane. In the former the joints are more nearly vertical and, in consequence, are more unstable. The direction in which the articular surfaces of the sacro-iliac joints face

FIG. 3

Photographs of a sacrum in the horizontal (*A*) and in the vertical (*B*) positions, showing the difference in direction in which the articular surfaces face. In the horizontal sacrum the surface of the joint faces outward, slightly upward, and backward, making a perfect inverted keystone to the pelvic arch. In the vertical sacrum the surface faces outward, slightly downward, and backward, thus making a true keystone to the arch. In the horizontal position the sacro-iliac joints support the weight of the body on their narrowest diameter; in the vertical position, on their longest diameter.

is of much importance and is very greatly affected by the position and inclination of the pelvis. When the pelvis is in the horizontal position (Fig. 3, *A*), the articular surfaces face outward, slightly upward, and backward, making a perfect inverted keystone to the pelvic arch. However, when the pelvis is in the vertical position (Fig. 3, *B*), the articular surfaces face outward, slightly downward, and backward, thus making a true keystone to the pelvic arch. In the specimen shown in Figures 4-A and 4-B a piece of wire was placed on the long diameter of the sacro-iliac joint and a nail on the short diameter at its widest point. In the horizontal position of the sacrum (Fig. 4-A), the sacro-iliac joints support the weight of the body on their narrowest diameter. In the vertical position (Fig. 4-B), the longest diameter takes the weight of the body.

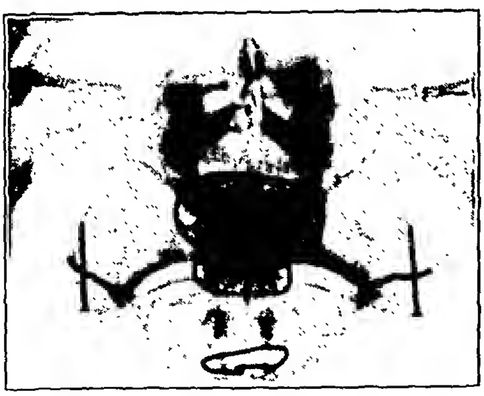

FIG. 4-A

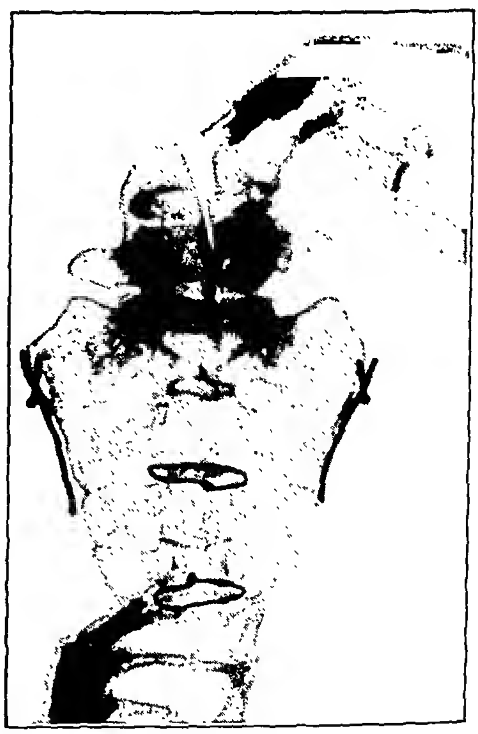

FIG. 4-B

Roentgenograms of a saerum in the horizontal (Fig. 4-A) and in the vertical (Fig. 4-B) positions. A piece of wire has been placed on the long diameter of the sacro-iliac joint and a nail on the short diameter at its widest point. This shows that in the horizontal position of the saerum the weight of the body is supported on the narrowest or shortest diameter of the saero-iliae joint. In the vertical position the weight of the body is supported on the longest diameter of the joint.

FIG. 5-A FIG. 5-B

Lateral roentgenograms of a bone specimen in which a wire has been placed, outlining the anterior edge of the sacro-iliac joint. Note that the sacro-iliac joint is roughly triangular in shape. With the sacrum in the horizontal position (Fig. 5-B), the base of this triangle is facing forward or even downward. In the vertical position (Fig. 5-A), the base of the triangle is more nearly upward.

When the pelvis is in the horizontal position, it must have rotated forward on an axis, the center of which is in the acetabulum or hip joint. In such a position the sacro-iliac joints have become anterior to the center of the acetabulum. When the pelvis is in the vertical position, these joints are above or posterior to the center of the acetabulum.

If we consider the sacro-iliac joints as triangles with two long sides and a narrow base, a horizontal sacrum (Fig. 5-B) means that the base of the triangle is facing forward or even downward. With the sacrum in the vertical position (Fig. 5-A), the base of the triangle faces more upward and thereby tends to act as a more effective keystone. When the sacrum is in the horizontal position, it has rotated forward on an axis, the center of which is in the acetabulum or the heads of the femora. In such a position the sacro-iliac joints are above or anterior to the center of the acetabulum or the heads of the femora. With the sacrum in the vertical position, the sacro-iliac joints are above or posterior to the center of the acetabulum and heads of the femora. Thus it can be seen that, from the weight-bearing and functional point of view, the markedly forward inclination of the sacrum cannot be an optimum position, because it must increase the strains on the sacro-iliac joints. Such a position also creates an equal, if not greater, strain on the lumbosacral and low lumbar articular facets. With the sacrum horizontal (Fig. 6-B), the lumbosacral joints are anterior to the center of the pelvic rotation in the acetabulum; this position necessitates a compensatory extension of the lumbar spine, the amount of which is dependent on the anatomical structure. With the sacrum vertical (Fig. 6-A), the lumbosacral joints are above or posterior to the center of rotation.

Figures 7-A and 7-B are roentgenograms of a patient who complained of backache in the low lumbar region as well as, at times, in such other parts as the thoracolumbar and midthoracic regions. A lateral view (Fig. 7-A) shows a moderately horizontal sacrum, and a marked lumbar curve with the spinous processes almost, if not completely, in contact and the articular facets jammed into the position of extreme extension, which means a narrowing of the intervertebral foramina. With such a potential of trouble, it is understandable how extra strain might cause pain referable to the sacro-iliac or the lumbosacral nerves. It will also be noted that the compensation for the position of the sacrum and the lumbosacral curve has caused the ribs to be in nearly a vertical position,—a condition which occurs with an increased thoracic curve, an increased cervical curve, and a forward position of the head. All of these compensatory curves have a very definite part in the strain on the low back. The treatment, therefore, must not only consist of flattening of the lumbar curve or the removal of strain by a fusion operation, but it must be aimed at correcting the mechanics of the whole body in order to relieve the strain on the lumbar and sacro-iliac joints. This patient was sixty years old. Figure 7-B, taken with the thighs flexed on the abdomen, shows how much motion can be obtained in the lumbosacral region. The lumbar curve is straight and the spinous processes are well apart. The intervertebral discs are sym-

FIG. 6-A

FIG. 6-B

Lateral roentgenograms of a bone specimen, showing that the lumbosacral joints in a horizontal pelvis (Fig. 6-B) are anterior to the center of pelvic rotation,—a position which necessitates a compensatory extension of the lumbar spine. With the pelvis vertical (Fig. 6-A), the lumbosacral joints are above or posterior to the center of rotation. This results in a decrease of the lumbar curve. (*Courtesy of the New England Journal of Medicine.*)

FIG. 7-A

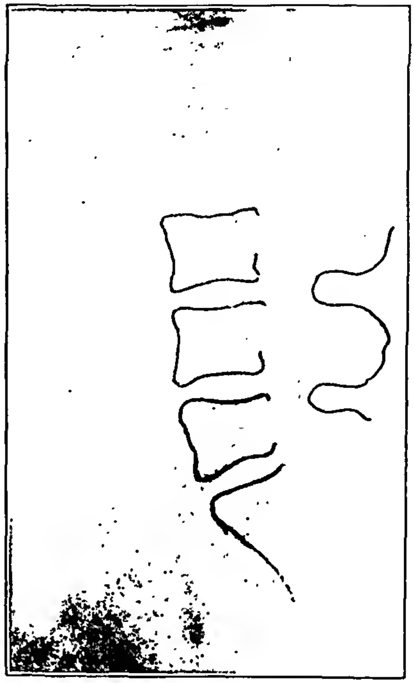

FIG. 7-B

Lateral roentgenograms of a patient who complained of backache and, at times, of pain in other parts, such as in the thoracolumbar and midthoracic regions.

Fig. 7-A: Note the horizontal sacrum and the marked lumbar curve with the spinous processes almost, if not completely, in contact. The articular facets are jammed into a position of extreme extension, which means a narrowing of the intervertebral foramina. Such a position is a potential of trouble if the spine undergoes an unusual strain.

Fig. 7-B: This shows how much motion in correction can be obtained in the lumbosacral region even in a patient sixty years old. This roentgenogram was taken with the thighs flexed on the abdomen. Note that the lumbar curve is straight and the spinous processes are well apart. The intervertebral discs are more symmetrical. The weight in this position would be carried on the discs and not almost entirely on the facets.

metrical in shape. In this position the weight of the body is carried on the discs and the articular facets act in their true capacity as stabilizers and do not carry almost all of the weight.

In conclusion, the criterion of whether any one type of treatment is efficient should not be only the relief of symptoms, because this can be obtained by that treatment with which the physician is most familiar. The criterion should be the same as we hold ourselves to in fracture work,—namely, has the treatment been successful in obtaining the best position for function that is possible for the entire anatomical structure involved?

ROOT PAIN RESULTING FROM INTRASPINAL PROTRUSION OF INTERVERTEBRAL DISCS

Diagnosis and Surgical Treatment *

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This report is based on a careful study of the records of fifty consecutive patients who have been operated on at The Mayo Clinic for protrusion of one or more intervertebral discs, producing either root pain or symptoms and signs of compression of the spinal cord. Prior to January 1, 1935, only eleven patients were operated on for protruded discs, or 2.3 per cent. of a series of 471 patients who were operated on for tumors of the spinal cord. Between January 1, 1935, and November 1, 1936, thirty-nine patients underwent laminectomy for abnormal protrusion of an intervertebral disc into the spinal canal.** During this same period, sixty-two additional patients were operated on for tumors of the spinal cord. Thus, of a series of 572 cases of verified intraspinal lesions that were causing compression on the spinal cord or roots, in fifty cases the compression was due to a protruded disc.

The part played by protruding discs in the production of neurological symptoms is receiving increasingly wide recognition. There has been a tremendous change in the percentage of protruded discs as compared with that of neoplasms of the spinal cord. This change has been brought about by increased ability to diagnose such lesions early. In this regard, the use of lipiodol in the intraspinal subarachnoid space in cases of intractable sciatica has contributed largely to the detection and localization of such lesions.

The whole-hearted cooperation of the orthopaedic consultants at the Clinic has made this report possible, since we in the Section on Neurological Surgery are dependent on them for the selection of many of these cases for neurological investigation and their opinions have aided us in avoiding the indiscriminate use of lipiodol intraspinally.

REVIEW OF LITERATURE

Goldthwait [9], in 1911, apparently was the first in this country to direct attention to the possible rôle of the intervertebral disc in the production of symptoms of "lumbago", "sciatica", and compression of nerves within the spinal canal. Middleton and Teacher [14], of Glasgow, in the same year reported the post-mortem findings in a case in which the symptoms

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** From November 1, 1936, to June 18, 1937, forty-five additional patients were operated on for protruded discs.

were due to protrusion of an intervertebral disc into the spinal canal. The work of Schmorl [21] on the pathology of the disc is classic, and his researches on the subject are without parallel; he, however, felt that the extruded disc did not produce neurological symptoms.

Adson [4], as early as 1922, in this Clinic performed laminectomy and removed a protruded disc which had been pressing on the cervical portion of the spinal cord with the consequent production of neurological symptoms in all four extremities. This patient is still alive and earning his living as a barber fifteen years after the operation. This case, incidentally, was included in a paper [1] on tumors of the spinal cord which was presented before the Seattle Surgical Society on January 8, 1925, and in which a drawing of the operative exposure of the disc was included.

In 1928 Stookey [22] reported seven cases of compression of the cervical portion of the spinal cord, resulting from protrusion of cervical intervertebral discs. In 1929 Dandy [8] reported two cases in which he had operated for protrusion of a lumbar intervertebral disc with paraplegia. He stressed the importance of trauma in the production of these lesions and the benefits to be derived from laminectomy and removal of the protruded fragments of disc. Bucy [5], in 1930, reported the case of a patient who had a tumor of one of the lumbar discs. This protrusion was removed and Bucy felt that the tissue represented a true neoplasm. Hawk [11], in June 1936, added ten cases to the literature and analyzed fifty from previous reports.

Neurosurgeons at The Mayo Clinic have for many years removed at the time of laminectomy extradural fibrocartilaginous masses from the spinal canal in cases in which the diagnosis was tumor of the spinal cord. It has been only in recent years, however, that we have come to look on these masses, not as neoplasms, but as abnormal protrusions of a normal unit of the spine,—namely, the intervertebral disc. In 1924 such a specimen, submitted to the surgical pathologist, was reported by him to be "fibrochondromatosis of the intervertebral disc". Formerly, these patients were operated on so infrequently and so late in the course of the process (in contrast to today) that at the time of operation the clinical picture was that of compression of the spinal cord such as is caused by a neoplasm. These cases were then usually classified as extradural tumors of the spinal cord. The work of Mixter and Barr [17], in 1934, served to focus attention on these cases, and since then the condition has been recognized earlier and operation is performed before the classic symptoms and signs of a neoplasm affecting the spinal cord develop. The paper by Mixter and Ayer [16] in 1935 again served to emphasize the frequency of occurrence of protruded discs with the production of root pain.

ETIOLOGY OF PROTRUDED INTERVERTEBRAL DISCS

It is our opinion at the Clinic that abnormal protrusion of an intervertebral disc into the spinal canal is, in the great majority of cases, the result of trauma. In this opinion we are in accord with most authors who

have written on the subject. We feel that the restraining annulus fibrosus is ruptured or weakened by undue stress and strain, whereupon the nucleus pulposus protrudes or herniates into the spinal canal with subsequent encroachment on the domain of the intradural or extradural nerve structures. Ribbert [20], in 1895, by a set of ingenious experiments, produced herniation of the nucleus pulposus anteriorly in rabbits by puncturing the intervertebral discs.

That puncture of the disc occurs only in experimental procedures on animals should not be entertained, for reports [15,19] have appeared in which attention has been called to the occurrence of this complication in the course of lumbar puncture either for diagnostic, therapeutic, or anaesthetic purposes. We have had no such case at the Clinic, but that this is a possibility can easily be seen. Protrusions of the discs that are recognized clinically and for which laminectomy is indicated occur posteriorly. That the disc may protrude anteriorly, however, cannot be denied. Whether or not such a lesion would produce symptoms, we are not prepared to say. Certainly, one would expect the protrusion to occur most often posteriorly because of the mechanical forces at work at the time of injury to the spine. Most of the injuries occur when the spine is in flexion. Thus the posterior portion of the annulus fibrosus is subjected to undue stress at the same time that the vertebral interspace is being narrowed anteriorly. This results in a squeezing of the compressible nucleus pulposus backward against an overstretched and weakened barrier. The barrier (annulus fibrosus) may not give way the first time, but, if subsequent injury occurs, extrusion of the nucleus, or indeed of most of the disc, may result. Overstretching may lead to degenerative changes, with subsequent protrusion of the disc without the occurrence of precipitating trauma immediately before the onset of symptoms.

PATHOLOGY OF PROTRUDED INTERVERTEBRAL DISCS

Dr. Kernohan [12] has been kind enough to collect the operative specimens obtained in this series of cases and has given us a report of his findings on microscopic study of the tissue.

Although there have been a variety of findings microscopically, the picture is essentially one of degeneration of the fibrocartilaginous constituents of the normal disc. The degenerative process may be slight or marked. Calcium, and even bone, may be found in the protruded portion of the disc. In some specimens, remnants of notochordal tissue are seen.

SYMPTOMS OF PROTRUSION OF INTERVERTEBRAL DISCS

The symptoms of protrusion of intervertebral discs into the spinal canal vary greatly, but the chief symptom is root pain and this pain is often unilateral. The pain may be referred to the peripheral distribution of one spinal-nerve root, or it may involve more than one peripheral segment, depending on the size and the location of the protrusion. For those not thoroughly familiar with neurological terms, "root pain" is defined as

pain which begins within or near the spinal cord and is projected peripherally to that part of the body or extremity innervated by the nerve fibers which leave the cord through the spinal-nerve root emerging at that level. The pain is often described as "sharp", "shooting", or "like an electric shock", and it is usually brought on or made worse by coughing, jarring, or sneezing. It is often precipitated by putting the particular nerve involved on tension, as by bending the neck or back. This phenomenon likewise accounts for the positive Kernig and Lasègue signs which are elicited when the roots of the sciatic nerve are compressed by an extruded disc. Intractable sciatica is often an expression of root pain, and frequently sciatic pain is the result of protrusion of an intervertebral disc.

In some cases the pain caused by a protruded disc does not suggest pain of the root type. Occasionally, patients complain only of "backache" or of "lumbago". The backache is often in the lower part of the back and simulates all the conditions, neurological and orthopaedic, which may occur in the region of the lumbosacral joint and the sacro-iliac synchondroses. Sometimes, though rarely, there is little or no pain and numbness or weakness is the complaint, which should attract the examiner's attention to possible involvement of the spinal cord or of its peripheral nerves. Paralysis of one or more extremities or of the vesical or anal sphincters is usually a late development, and one should strive to make an accurate diagnosis and remove the cause before such serious symptoms develop. In one of our cases at the Clinic, paralysis of the lower extremities, the bowel, and the bladder developed within three months of the onset of pain. The process was so rapid, in fact, that a malignant neoplasm was suspected prior to the introduction of lipiodol and fluoroscopic observation. In another case (Fig. 1), that of a man with a protruded cervical disc, a transverse lesion of the cord with loss of sphincteric control developed within a month from the date of onset of symptoms.

There are no physical, neurological, or orthopaedic signs which are found alone in cases of protrusion of intervertebral discs. All of the known signs may also be found in other conditions.

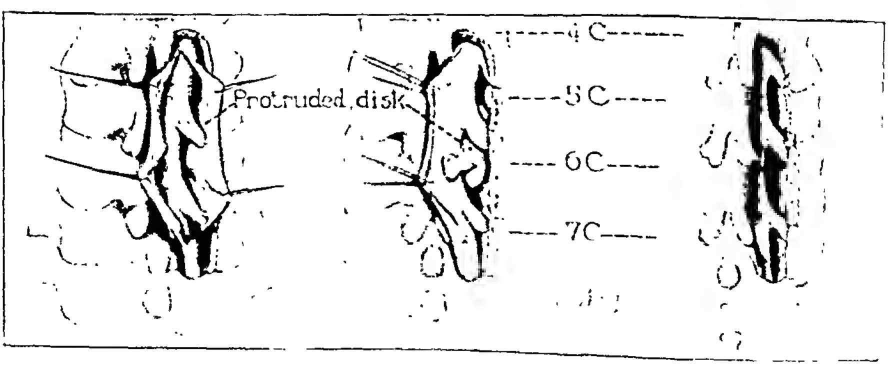

Fig. 1

Removal of protruded fifth cervical intervertebral disc, resulting in cure.

ROENTGENOGRAPHIC DIAGNOSIS

The roentgenographic diagnosis and localization of protrusion of an intervertebral disc into the spinal canal is dependent on the use of a radiopaque oil which is injected into the subarachnoid space. An analysis of the changes observed in the plain roentgenograms in this series of fifty cases further substantiates our opinion and that of others[10, 16] that ordinary roentgenograms are of little value in the diagnosis. It would seem that in any condition in which trauma is such a common etiological factor there should be visible in plain roentgenograms some alteration in bone or joint structure to denote the site of the lesion. For this reason, it is interesting to review the changes most frequently observed in the spine, as regards their relation to the site of the protruded disc, and to see wherein they may be either of some value or else misleading.

There were fourteen cases in which the plain films were negative and were of no help whatever in the subsequent diagnosis. In one case (Fig. 2) the lesion was partially calcified and ossified and was clearly visible within the spinal canal just posterior to the body of the seventh cervical vertebra.

FIG. 2

Overlying the body of the seventh cervical vertebra there is an irregular shadow of increased density produced by calcium and bone within a protrusion of the seventh cervical disc.

Narrowed Intervertebral-Joint Space

The question is often raised as to the relation of a narrowed intervertebral-joint space to intraspinal protrusion of the associated disc. In this regard we have always stated that such a finding was of little significance, because narrowing of the intervertebral space at the site of a protruded disc occurred consistently in only a small percentage of cases. Such a finding may also result from degeneration and fibrosis of an intervertebral disc without protrusion, and many patients in whom such a change is observed are free from any symptoms that could be attributed to a lesion at that level. The data concerning the presence of narrowed intervertebral discs in this series of cases are worthy of comment. In twenty-seven cases a narrowed intervertebral-joint space was observed at one or another point in the spinal column. In nineteen instances the narrowed disc or discs were at a different level than the site of the lesions found at operation. In sixteen instances the level of the narrowed intervertebral-joint space coincided with the site of the lesion which was removed by the surgeon. While this would appear at first to be significant, the presence of multiple, narrowed intervertebral-joint spaces in ten of these sixteen cases makes the occurrence of a protruded disc at one segment of little relative importance.

The fourth and fifth lumbar intervertebral-joint spaces were most frequently narrowed and there were fifteen instances of each. In the group of cases with a narrowed fourth lumbar joint space, a corresponding surgical lesion was found in six instances. In fifteen cases of a narrowed fifth lumbar intervertebral-joint space a corresponding surgical lesion was demonstrated in nine. While this suggests that a narrowed fourth or fifth lumbar intervertebral-joint space is of some importance, the complete data indicate that there is no dependable and consistent relationship between a narrowed intervertebral-joint spaee and the presence of a protruded disc at the same level.

Hypertrophic Changes

In seventeen of the fifty cases there was evidence of hypertrophic changes about the margins of one or more intervertebral-joint spaces. In only five cases, however, were the hypertrophic changes localized about the margins of the intervertebral joint at the site of the lesion. It is quite evident, therefore, that the presence of proliferative changes in bone is of no help in the direct localization of protruded intervertebral discs.

Compression Fractures

In this series, a compression fracture of one or more vertebral bodies was rare. Such a combination occurred in only three cases, and in two of these cases the protruded disc was quite remote from the level of the compression fracture. In the third case a protruded disc was removed from the eleventh thoracic intervertebral space and an old compression fracture of the bodies of the twelfth thoracic and the first lumbar vertebrae was present. This group is probably too small to establish a dependable relationship between fraeture and disc protrusion.

Examination with Lipiodol

In fourteen cases a study of the spinal subarachnoid space by means of lipiodol was not carried out; nine of these patients were operated on prior to 1930 and five in subsequent years. The neurological examination in each case so clearly established the level of the lesion that operation was carried out directly with the expectation of finding a tumor affecting the spinal cord. This experience indicates that the use of lipiodol is not always necessary to localize the level of a lesion, especially when it is above the conus medullaris. The use of lipiodol, however, is necessary whenever it is desirable to establish with reasonable certainty preoperatively whether the lesion is a protruded disc, a tumor, or inflammatory disease. This is particularly true in the case of lesions below the conus medullaris wherein the clinical localization of compression to individual nerve roots is extremely difficult. The use of lipiodol indiscriminately in all cases of persistent low-back or sciatic pain is not to be recommended. As stated elsewhere in this paper, certain criteria that may be determined from a carefully taken history and physical examination, and more significantly

from the results of examination of the spinal fluid and epidural injection, should be present before a study with lipiodol is considered. The use of lipiodol is always associated with a certain degree of risk, for we recognize that it has certain irritant properties in the subarachnoid space. However, in the properly selected case, we feel that the information to be derived from its use far outweighs any disadvantages that it may have. Its use in the case of recognized inflammatory disease is not recommended.

The procedure that we employ for the roentgenographic identification of protruded intervertebral discs by means of lipiodol is the same that we have used for several years for the localization of tumors involving the spinal cord. In the past, one of us [7] has emphasized the necessity of using sufficient radiopaque oil (five cubic centimeters) to fill the subarachnoid space at any desired level, in order to visualize small non-obstructing tumors which can be identified by a filling defect; this defect assumes a characteristic shape depending on whether the lesion is extradural, intradural, or intramedullary. Since the majority of protruded intervertebral discs produce no obstruction and occur in a region where the spinal canal is relatively large, it is hopeless to attempt to visualize or to locate them by means of one or two cubic centimeters of radiopaque oil, which can easily trickle past the lesion without any significant changes in contour.

Technique

The lumbar injection is preferred. After injection, the patient is placed in a sitting position on the fluoroscopic table for about one minute in order to permit all of the oil to gravitate to the sacral cul-de-sac. This being done, the patient is placed in the prone position on a tilting fluoroscopic table with the foot end of the table depressed to prevent cephalad excursion of the oil until the actual fluoroscopic observation is started. The shoulders are supported by padded shoulder rests. If the oil is seen to be low down in the lumbar canal, the foot of the tilting table is gradually elevated and the shadow of the oil as it moves cephalad is carefully observed (Fig. 3).

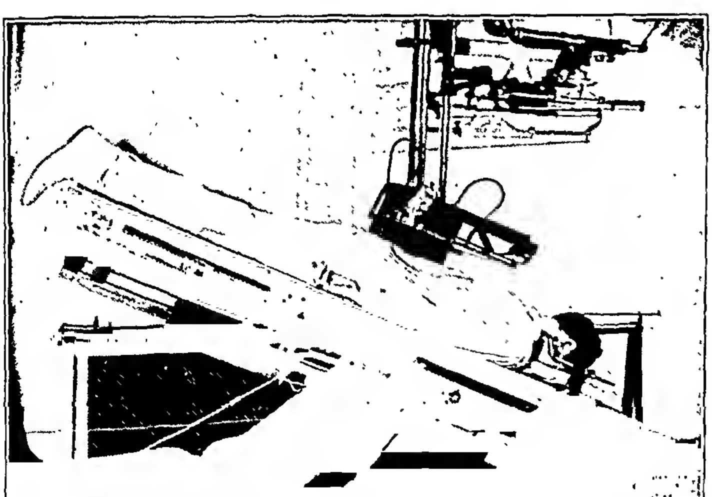

FIG. 3

Tilting fluoroscopic table, showing one phase of the examination during the cephalad excursion of the lipiodol. Note the padded shoulder rests that support the patient.

When the pupils are properly dilated, it is easy to recognize

the intervertebral-joint spaces and to observe their relation to any defects that may appear. If the symptoms indicate that the lesion involves the lumbar roots, it may not be necessary to observe the movement of the oil much above the conus medullaris. However, we routinely follow the oil to the cervical region in all cases in an effort to pick up multiple associated or unsuspected lesions. Since protruding discs are situated in the anterior portion of the spinal canal, they produce their maximal filling defect when the patient is lying prone. In this position the heavy oil will gravitate to the ventral aspect of the subarachnoid space and is in close contact with the protruding disc. If a persistent defect is observed, films should be made as quickly as possible without disturbing the position of the patient. The most satisfactory results are obtained when a film is substituted for the fluoroscopic screen and the exposure made with the tube beneath the table. The modern "spot-film" devices for fluoroscopy and roentgenography of the stomach are ideal for this work since they permit a rapid change from fluoroscopy to roentgenography. This is extremely important, for if one wishes to record on films the appearance of the fluoroscopic image, which to our minds is the most significant part of the examination, it is necessary to have some means of roentgenographing the lipiodol "on the move".

Whether or not a defect is observed, fluoroscopic examination should include observations in the prone-oblique and lateral positions. Only by this means is it possible to determine accurately the anterior or anterolateral position of a mass that indents the column of lipiodol. After the excursion of lipiodol has been studied in the foregoing positions, we routinely have the patient sit up again for one minute in order to collect the oil in the sacral cul-de-sac, and then repeat the examination with the patient supine. Many protruded discs will not produce a recognizable deformity when the patient is supine; nevertheless, we feel that this part of the examination is necessary in order to determine confidently whether or not a tumor of the spinal cord is present. The presence of a tumor of the spinal cord in addition to a prolapsed disc is not improbable and two such cases have been reported by one of us [6].

Defects in the Column of Lipiodol *

Because the protruded fragment of the disc is extradural, it will push against the column of lipiodol in the subarachnoid space, on the ventral or ventrolateral aspect, and indent it or displace it posteriorly and sometimes laterally. Complete obstruction of the column of lipiodol has been observed in the case of large protrusions. The classic filling defect is a sharply defined, rounded indentation in the lipiodol shadow on one side of the midline opposite an intervertebral disc (Fig. 4, *a* and *b*). The extent

* The discrepancy between the figures given in this section and those given in the surgical section results from the fact that the surgical data include fourteen cases in which examinations with lipiodol were not made, two cases with double lesions in which the obstruction produced by one lesion prevented the second lesion from being seen, and one case in which the examination with lipiodol was negative.

FIG. 4
Characteristic defect in the column of lipiodol produced by a protrusion of the third lumbar intervertebral disc: *a*, prone position; *b*, prone-oblique position.

of this defect is influenced naturally by the size of the protrusion. It is generally better defined in a prone-oblique position, and may or may not be evident in the lateral view.

In twenty-two cases the defect was unilateral,—on the right side in ten and on the left in twelve. The defect was bilateral in twelve cases. In six cases multiple defects were observed (Fig. 5, *a* and *b*). In one case the lateral view was the only position that revealed the defect, and in the remaining case examination with lipiodol was reported as negative. No obstruction to the flow of the lipiodol was evident in twenty-nine cases. There were four cases of partial obstruction and three of complete obstruction. In two of the latter cases the complete obstruction prevented the visualization of a second lesion of the adjoining disc (Fig. 6, *a* and *b*).

In addition to the outline of the defect produced by the mass of the protruded disc, significant changes in the shadows of the nerve roots may be present at the level of the lesion. These consist of oedema of one or more nerve roots, which may be recognized by a broadening of the negative shadow of the nerve root if it is outlined (Fig. 7), and by displacement or deformity of the shadows of nerve roots within the subarachnoid space. If the oil has extended into the extradural portion of the nerve sheath, displacement or deformity of this root may occasionally be visible. In a few cases the shadow of the oil in the extradural portion of a nerve sheath was terminated sharply at the level of the protruded disc, suggesting pressure at this point. In some instances in which several nerve sheaths were

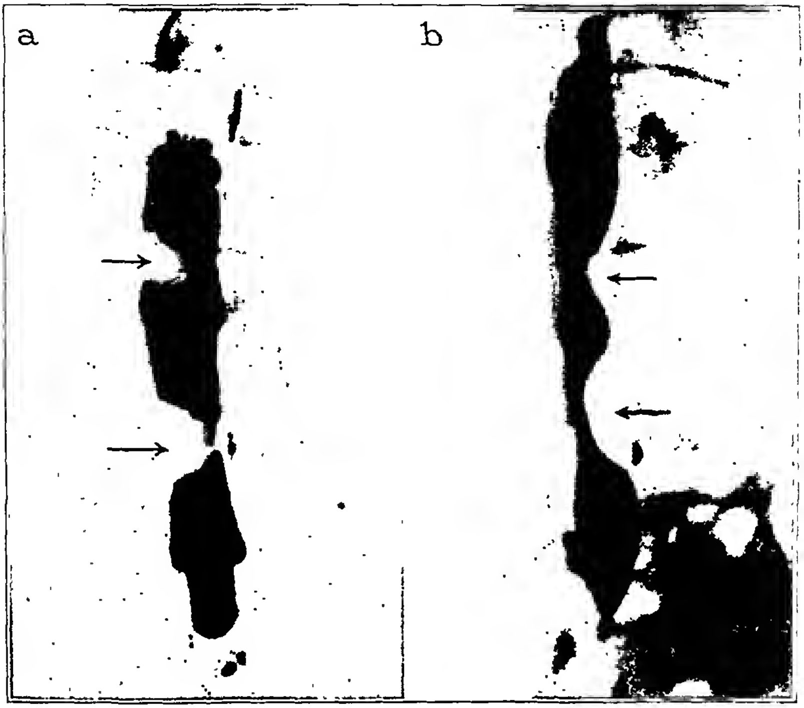

Fig. 5

Multiple defects in column of lipiodol produced by a protrusion to the left of the third and fourth lumbar intervertebral discs: *a*, prone position; *b*, prone-oblique position.

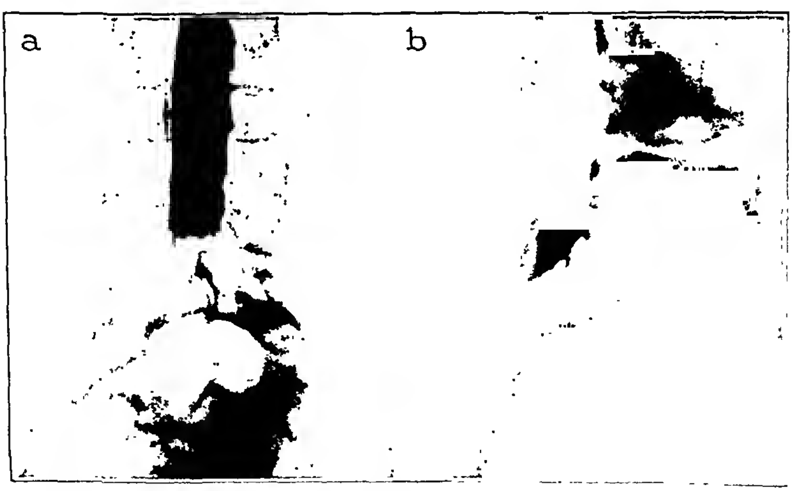

Fig. 6

Complete obstruction of the column of lipiodol produced by a large protrusion of the fourth lumbar intervertebral disc. Because of the complete obstruction, a second protrusion, involving the fifth lumbar intervertebral disc could not be visualized: *a*, prone position; *b*, lateral position, revealing posterior displacement of the lipiodol shadow at point of obstruction.

visible, it was noticed that there was persistent non-filling of the sheaths on the side of the lesion; this is probably of significance and suggests pressure or oedema of the nerve. However, nerve sheaths fill so inconsistently that lack of filling on one side cannot be depended upon as a reliable sign of protrusion of the disc.

The distribution of defects revealed by studies with lipiodol in this series was as follows: tenth thoracic, one; eleventh thoracic, two; twelfth thoracic, one; first lumbar, one; second lumbar, one; third lumbar, eight; fourth lumbar, fifteen; and fifth lumbar, fourteen. There were six cases of multiple protrusions, which were distributed as follows: third and fourth lumbar, three; fourth and fifth lumbar, one; third and fifth lumbar, one; and one case in which all the discs between the eleventh thoracic and the fifth lumbar vertebrae were involved.

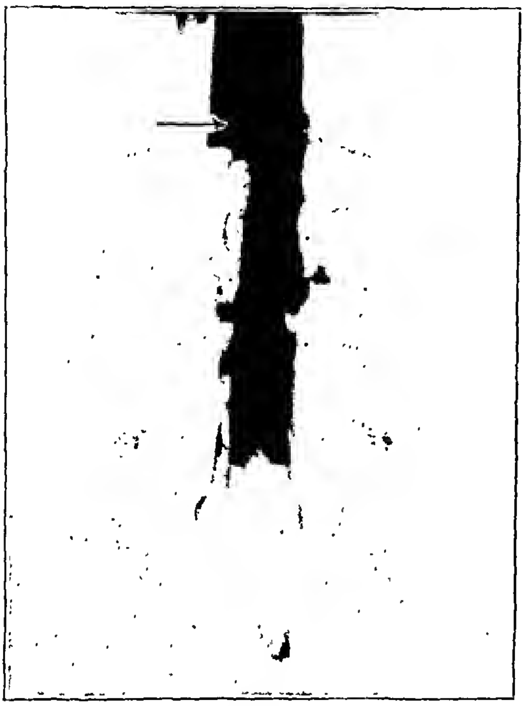

Fig. 7

Compression of lipiodol by a protruded third lumbar intervertebral disc. The arrow indicates an oedematous fourth lumbar root medial to which the fifth lumbar root may be seen.

Examination of the region of the lumbosacral joint requires in most cases an additional manoeuver, because there is not available in the United States any tilting fluoroscopic table that will permit both ends of the table to be raised to a vertical or nearly vertical position, which is necessary in order to move the lipiodol into the sacral cul-de-sac and also into the upper portion of the spinal canal when the patient is in the prone position. When the patient is in this position, the sacrum curves upward and the lipiodol will not move across the lumbosacral junction dorsally into the sacral cul-de-sac unless the foot end of the table can be tipped down to an angle of at least 45 degrees. Since the maximal downward tilt of one end of most fluoroscopic tables is limited to about 20 degrees, it is necessary to reverse the position of the patient on the table in order to obtain a tilt great enough to fill the sacral cul-de-sac. In our routine investigations with lipiodol for protruded discs this is the concluding step of the examination. After the areas above the lumbosacral joint have been examined, the table is brought back to a horizontal position and the patient is allowed to sit up long enough to substitute a foot rest for the shoulder rest. He is then placed prone on the table again with his head at the end formerly occupied by his feet. The head end of the table is then elevated as much as necessary to produce filling of the sacral cul-de-sac. Because of the gradual fusiform narrowing

of the terminal portion of the subarachnoid space and the proportionately larger spinal canal at the fifth lumbar vertebra, protruded discs at the lumbosacral junction will not produce as marked filling defects as they would at higher levels. Since it is desirable to fill the sacral cul-de-sac as completely as possible in order to visualize the maximal effect of any protrusion, it may be necessary to raise the patient to almost a standing position.

Hampton and Robinson's recent work [10] has placed the lipiodol findings in cases of protruded discs on a definite anatomical and pathological basis, a knowledge of which is fundamental to a successful and conclusive examination. They call attention to the fact that the fifth lumbar root and most of the first sacral root are extradural at the lumbosacral junction, and, therefore, are outside the confines of the lipiodol in the subarachnoid space unless it has followed along their nerve sheaths. For this reason, a lesion compressing either of these roots may produce a minimal defect in the contiguous subarachnoid space. Examiners and neurosurgeons should, therefore, not be surprised when the size of the protruded fragment removed at the lumbosacral junction is not in keeping with the extent of the defect in the column of lipiodol.

DIFFERENTIAL DIAGNOSIS

In the differential diagnosis of protrusion of an intervertebral disc there are many conditions to be considered. Chief among these is intraspinal neoplasm, but since the treatment is the same for the two conditions—namely, laminectomy and removal—this should not concern us unduly. In fact, a protruded disc is just as much a tumor of the spinal cord as is an endothelioma arising from the spinal meninges, and a protruded disc can produce paralysis and sphincteric disturbances, with resulting infection in the urinary tract and death, just as well as can a primary neoplasm. It is, of course, true that a protruded disc is not a neoplasm, for it does not grow in the sense of neoplasia, but it does tend to increase in size and, in time, just as much damage may be done to the spinal cord and its nerves as by a true neoplasm.

The conditions which most closely resemble protrusion of the intervertebral disc are: low-back pain (whatever its cause), lumbosacral strain, sacro-iliac disease, spondylitis, and hypertrophic changes involving the spine. Likewise, brachial-plexus or lumbosacral-plexus neuritis may be the diagnosis in a given case until examination of the spinal fluid reveals an increased total protein, and fluoroscopic study with lipiodol then discloses the real cause of the painful condition. Usually there is a paucity of neurological findings in cases of protrusion of the discs, but in some cases there is definite and well-marked evidence of disease of the spinal cord. In some of these cases the clinical picture may be that of syringomyelia or multiple sclerosis. In one of our cases at the Clinic, because of an associated severe diabetes mellitus, the diagnosis of diabetic neuritis was entertained until fluoroscopic study with lipiodol settled the question.

Sciatic neuritis and fibrositis have likewise given trouble in cases in which the condition finally proved to be due to a protruded intervertebral disc.

It is not within the scope of this paper to go into the diagnosis of each of these conditions. It is suggested only that, when a patient has received the usual recognized conservative treatment for the condition from which he is considered to be suffering, without appreciable benefit, the possibility of a protruded disc be considered as the cause of his disability. This condition should always be considered in cases of intractable and recurrent "sciatica".

TREATMENT

Protruded discs that are not causing compression on nerve roots or spinal cord probably do not require any treatment, at least it is not our policy at the present time at the Clinic to advise laminectomy unless the defect in the column of lipiodol opposite the disc corresponds to the neurological level of clinical symptoms. For instance, in the course of fluoroscopic study of the column of lipiodol in the spinal canal, we have found defects classic for a protruded disc, but we have not advised laminectomy because the defect was in the lumbar region and the patient had symptoms and signs indicative of a lesion involving the thoracic portion of the spinal cord.

When the defect is at such a level that a mass at that level could produce the symptoms and signs elicited by the history and on neurological examination, laminectomy for removal of the protruded portion of the disc is advised. Laminectomy in such cases is just as necessary as laminectomy for removal of an intraspinal neurofibroma or meningioma. Decompressive laminectomy is not sufficient. The protruded fibrocartilaginous mass must be removed if the patient is to receive the optimal amount of relief from his symptoms.

The anaesthetic of choice is ether and this is best administered by the open drop method over the end of a Magill intratracheal tube which has been introduced after the patient has been anaesthetized by nitrous oxide and oxygen. The patient is then placed on the operating table as for any laminectomy. We at the Clinic prefer to perform cervical laminectomies with the patient in the upright position [3]; other laminectomies are performed with the patient prone, the torso being supported by two rolled pillows, so that there is no interference with breathing. When the lesion is low in the lumbar region or at the lumbosacral space, a large, soft, flat pillow is placed across the lower ends of the rolled pillows and between the symphysis pubis and the xiphoid process in order to increase the prominence of the lumbar spinous processes. This facilitates exposure in the lumbar region where the muscles are quite large and the distance from the skin to the anterior surface of the dura mater (or disc) is greater than that at any other level of the spine.

Subperiosteal resection of the spinous processes and laminae of the two vertebrae between which the protrusion has occurred is sufficient for

adequate exposure and removal of the disc. Occasionally laminectomy is necessarily more extensive, and often only a portion of the laminae of one of the vertebrae needs to be removed. If protrusion has occurred in the midline in the lumbar or lumbosacral region, laminectomy does not have to be wide; however, if the protrusion is lateral, as it frequently is, it may be necessary to remove the articulating facets on that side in order to secure adequate exposure, thorough removal of the protruded disc, and thereby adequate decompression of the involved nerve root. Whenever possible, laminectomy should be narrow and the facets should be preserved. This maintains normal stability of the spinal column following operation. In the cervical and thoracic regions, wide laminectomy, at least on one side, is the rule, for here the spinal cord must be rotated in order to obtain satisfactory exposure. Section of one or more teeth of the dentate ligament facilitates rotation of the cord.

Unilateral protrusions in the cervical region can be removed by hemilaminectomy. This procedure is always preferable when one is dealing with intraspinal lesions in the cervical region, because the neck is left in a more nearly normal condition after operation, and, in spite of the free motion of the cervical spine, there is little or no danger of its dislocation,—a condition which does occur, although rarely, following bilateral cervical laminectomy [2].

The protruded disc may be removed extradurally or transdurally. We at the Clinic have no set rule in regard to this, for the operation should be adapted to the particular case after laminectomy has been performed. If the protrusion has occurred to one side, extradural removal is the procedure of choice and it can be accomplished without difficulty. If the protrusion is in the midline, and particularly if the extruded mass is small, transdural removal is easier and is accompanied by less bleeding. If the dura is retracted for an anterior extradural approach to a small herniation of the disc, bleeding from the extradural vessels is likely to be sharp and very troublesome. In the case of larger lesions either approach may be used without encountering much bleeding. It is our feeling that the extradural veins are either thrombosed or sufficiently displaced by the larger protrusions, so that they are not injured during the removal of the mass, and, consequently, hemorrhage is less. The consistency of the protrusions varies considerably,—some are bony and hard, others are soft and fluctuant. The fluctuant masses should be aspirated with a small needle to exclude the possibility of pus in a tuberculous lesion before the mass is incised, for to incise such a lesion in the presence of an open dura mater is fatal.

From the point of view of surgical anatomy, protrusions are of two kinds: (1) those that pop out (Fig. 1) when the dura mater is retracted and the thinned-out posterior longitudinal ligament is incised, and (2) those that are firmly adherent to the adjacent vertebrae and require sharp dissection for their removal. The former at times pop out and need only to be picked up with forceps when the overlying dura mater is retracted,

the posterior longitudinal ligament overlying the disc having been completely destroyed. Destruction of the ligament might be the cause or the result of protrusion of the disc; it is our feeling, however, that it is the result rather than the cause, for many protruded discs are seen that are still partly held in place by the intact ligament. Incision of the ligament in such cases allows the protruded disc to become much more prominent, and after incision, with release of the restraining force exerted by the ligament, the nucleus pulposus and a portion of the annulus fibrosus may be found lying free posterior to the ligament and anterior to the dura mater.

All protruded tissue that is causing or could cause pressure on the nerve roots or spinal cord should be removed. When removal has been completed, the anterior and lateral surfaces of the spinal canal should be smooth and there should be no encroachment upon the canal.

In spite of meticulous care in the performance of laminectomy and the removal of the protruded disc, drainage usually is necessary for a period of from twenty-four to forty-eight hours. Rarely a wound is closed tightly without a drain. Often a Penrose cigarette drain, left in just above the level of the dura mater for twenty-four hours, is sufficient; however, it is frequently necessary to use one or more strips of plain gauze packing, one inch in width, between the dura mater and the site where the disc was removed. The disc itself is avascular, but the surrounding extradural structures are very prone to ooze.

Patients are kept in bed for from twelve to fourteen days following operation, during which time they rest on soft pillows so arranged as to keep the spine straight. They are turned every four hours. The skin sutures (silk or dermal) are removed on the tenth postoperative day. Catheterization is performed every eight hours if the patient is unable to void. If voluntary urination does not occur by the third day, an inlying urethral catheter is placed for continuous drainage of the bladder until the patient is out of bed. The inlying catheter and the bladder are irrigated twice daily with a 4-per cent. solution of boric acid, and seven and one-half grains (0.48 grams) of methenamine and fifteen grains (1.0 gram) of ammonium chloride are given by mouth three times daily. In our experience this is the best way to avoid cystitis and infections of the urinary tract. The catheter is removed after five days and is replaced by another sterile catheter. Of course, all catheterizations are done under as nearly aseptic conditions as possible. Patients are allowed to sit on the edge of the bed on the twelfth or fourteenth day and in a chair the next day, and they are permitted to walk the following day. After being up in the hospital for a few days they report to the office for postoperative examination, and they are allowed to leave town for their homes by the end of the third week following operation. They are advised to refrain from heavy lifting and straining for a period of three months, after which time they are encouraged to return gradually to their former activities. No braces or special supports are advised.

ANALYSIS OF CASES

As has been stated, this study consists of a careful analysis of the records of fifty consecutive patients who were operated on at The Mayo Clinic by members of the neurosurgical staff, prior to November 1, 1936, for the protrusion of one or more intervertebral discs. In each case the diagnosis was verified at the time of laminectomy. Cases in which a diagnosis of a protruded disc was made, but in which, for one reason or another, laminectomy for removal of the protruded disc was not performed, are not included in this series. Likewise cases of extradural chondroma or chordoma are not included.

Although any intervertebral disc may protrude into the spinal canal, with the subsequent production of compression on the spinal cord or nerve roots, the discs in the lumbar region are most commonly involved. In our fifty cases there were forty-two instances of protrusion of the lumbar discs (thirty-eight patients) as against seven protruding thoracic discs and only five cervical discs. Multiple protrusions were found five times in the lumbar region, and once in the thoracic region. Not only are protrusions found most often in the lumbar region, but certain discs seem to be more vulnerable than others. For instance, the fifth lumbar or lumbosacral disc was protruded in twenty cases, the fourth lumbar in sixteen, the third in five, and the first and second each in one case. In the thoracic region, the fifth, sixth, and eleventh discs were found to be protruded in two cases each, whereas in the seventh case involvement was of the tenth thoracic disc. In the cervical region, the fifth and seventh discs were each found to be protruded in two cases. In a fifth case, protrusion occurred at the sixth disc.

Pain is the chief complaint in cases of protrusion of the discs and it may well be the only one. It was the chief symptom in forty-five of the fifty cases, there being only five patients who did not complain of pain. The next most important point to determine in taking the history is whether the patient has had an injury to the spine (excluding vertebral fracture, for the disc is rarely protruded in cases of fracture of the vertebra) or whether he has subjected the back to any unusual stress or strain. In thirty-seven of the cases there was a history of trauma to the spine. Trauma may be followed immediately by pain in the back and down one or more extremity, or pain and disability may occur after an interval of weeks or months.

The condition occurs most frequently in males, as one would naturally expect, since it is the male who more often subjects his back to unusual stresses and strains and is often employed where accidental injury is liable to occur. That thirty-nine of the patients in this series were males is confirmatory of this statement.

Apparently, protrusion of an intervertebral disc may occur at any age, although, as is to be expected, it is seen most often in the third, fourth, and fifth decades of life. The youngest patient in this series was sixteen years old (and she had had symptoms for five months prior to operation)

and the oldest patient was seventy-three. The average age for the group was thirty-nine and eight-tenths years.

Ordinarily the symptoms for which the patient seeks relief have been present for a long time when he finally comes to operation for removal of a protruded disc. All of the usual conservative methods of treatment for lumbago, low-back pain, sacro-iliac strain, lumbosacral pain, sciatica, arthritis, and neuritis ordinarily have been tried before an accurate diagnosis is made and the proper curative treatment is instituted.

Those patients who have protrusions of the discs in the cervical and thoracic regions come to operation sooner than those whose lesions are in the lumbar region. This is explained, we believe, on anatomical grounds, for, in the cervical and the thoracic regions, the spinal cord occupies most of the spinal canal and a small intraspinal tumefaction will cause compression and neurological signs relatively early; whereas, in the lumbar region, the dural envelope can be encroached upon to a considerable degree before symptoms and signs other than those of root pain are produced. In our series of cases the average duration of symptoms before removal of the offending protruded disc was one and four-tenths years (shortest, one month; longest, three years) for the cervical group; two and four-tenths years (shortest, one month; longest, seven years) for the thoracic group; and, for the lumbar group, four and eight-tenths years (shortest, one month; longest, twenty-four years).

Of the forty-five patients with pain, twenty-six complained of low-back pain and pain along the course of one or both sciatic nerves; eleven patients gave a history of sciatic pain only; and four patients reported low-back pain without sciatic projection. The other four patients referred the pain to the neck, the upper extremities, or the upper portion of the spine. Of these forty-five patients, the pain was unilateral in thirty and bilateral in fifteen. Thirty-seven patients suffered from pain along the course of the sciatic nerve or its branches. Persistent, intractable, sciatic pain should, therefore, arouse suspicion as to the possibility of a protruded lumbar intervertebral disc as the underlying cause.

Neurological examination should be carried out in each case, and care should be exercised to detect slight deviations from the normal, as marked neurological changes are rarely found. Often diminution of an Achilles-tendon reflex, associated with a positive Lasègue sign on the same side, will constitute the sole neurological finding. The projection of the pain as described by the patient should be noted carefully, and, even though a protruded disc is found later, operative removal of the disc, with the promise of relief, should not be advised unless the abnormal disc corresponds to the level of root pain.

Although the neurological findings were usually slight, some variation from the normal was noted in forty of the fifty cases analyzed. Often the sole finding was a diminished or absent Achilles-tendon reflex on the side of the pain. In fifteen cases a diagnosis of compression of the cord or cauda equina, with the level of compression, was made on the basis of the

neurological findings, and fourteen of these fifteen patients were operated on without the use of intraspinal lipiodol. A protruded disc, which was causing the compression and symptoms, was identified in each case.

Lumbar puncture to determine the hydrodynamics of the cerebrospinal fluid, and for the purpose of obtaining a specimen of fluid for chemical and microscopic examination, is indicated in all cases of persistent pain which partakes of the nature of radicular involvement. Queckenstedt's test should be performed routinely to determine the presence or absence of subarachnoid block above the level of the spinal-puncture needle. In cases of a protruded disc, this sign is negative most of the time, but, when positive, it is of the utmost importance. This test is much more frequently positive in cases of intraspinal neoplasm. In this series only four patients were found on lumbar puncture to have subarachnoid block. One of these patients had an intraspinal meningioma which was producing the block, and the meningioma lay above the protruded disc which was causing root pain. One patient had a large protrusion of the first lumbar disc. The other two patients had a definite sensory level on neurological examination and, at operation, the protrusion of the fifth cervical disc in one case and of the sixth cervical disc in the other was found to be of sufficient size to cause complete block of the cervical canal. No doubt more instances of subarachnoid block would be found in cases of protrusion of vertebral discs if the subarachnoid space were punctured below the lesion; however, owing to the fact that these protrusions occur most often low in the lumbar region, the needle most frequently is above the lesion, and, consequently, no block could be expected.

The cerebrospinal fluid is examined for evidence of syphilis; a cell count and determination of the total protein are made; the fluid is examined for the presence of globulin; and a colloidal curve is charted. The most important test is the determination of the total protein. It was thought for a time that a total-protein reading greater than forty milligrams per 100 cubic centimeters was essential before a diagnosis of a protruded disc could be considered. However, it has been learned that this is not true. Spinal fluid was obtained for examination in forty-nine of the fifty cases, but no report of the total-protein content was made for one reason or another in eight of these. Most of these cases were seen early and before routine determinations of total protein of the cerebrospinal fluid were being made. The highest value for total protein was 360 milligrams; the lowest, twenty milligrams per 100 cubic centimeters of fluid. We have arbitrarily set forty milligrams of total protein per 100 cubic centimeters of fluid as high normal. In this group of forty-one cases in which the total protein was estimated, there were thirty cases in which the total protein was greater than forty milligrams per 100 cubic centimeters of fluid. Thus, there were eleven patients, found to have protruded intervertebral discs that were causing symptoms, in whom the protein content of the cerebrospinal fluid was normal. Again, we would like to

emphasize the point that in the majority of cases the fluid sent to the laboratory for examination is obtained above the level of the protruded disc.

Because of this fact, we have come to lay considerable stress on the value of a procedure which we term the "reverse" Queckenstedt test [13]. With a spinal-puncture needle in the lumbar canal, 1-per-cent. procaine hydrochloride is injected into the caudal epidural space. This procedure has not been done routinely, and it was performed in only twelve cases in this series. In seven of these twelve cases, there was a positive reaction, which definitely suggested the presence of a lesion involving the cauda equina. When a solution is injected extradurally into the sacral hiatus, the dura mater is compressed and, if there is a lesion that is already compressing one or more roots of the cauda equina, unbearable pain in the distribution of the involved root will follow as further encroachment on that root is produced. Ordinarily, as the solution is injected extradurally, there is a rise in intraspinal pressure, as determined by the manometer attached to the spinal-puncture needle in the lumbar region. If a low-lying caudal lesion of sufficient size to obliterate the caudal sac is present, no increase in the manometric reading will be observed.

Unless a definite level of motor or sensory loss is determined on neurological examination, subarachnoid injection of a radiopaque oil for fluoroscopic and roentgenographic examination of the spinal canal is essential to establish the diagnosis of an intraspinal lesion. Lipiodol in experienced hands not only enables the making of the diagnosis of intraspinal lesion, but, in the majority of cases, it is also possible to state that the lesion is a protrusion of a certain intervertebral disc. Intraspinal lipiodol was employed in thirty-six of the fifty cases. If such a study is negative for an intraspinal lesion, laminectomy for removal of a protruded disc should not be considered, for, in experienced hands, the smallest of defects can be diagnosed and localized by this technique.

When the diagnosis of protrusion of an intervertebral disc has been made, and if the protruded disc is at a level that could account for the patient's symptoms, the treatment is laminectomy and removal of the protruded portion of the disc. Rarely, it may be necessary to conclude the operation after laminectomy has been performed and the protruded disc has been identified, but the results of a decompressive operation alone militate against this procedure as a method of treatment. In six of the present series of fifty cases the disc was not removed. Two of these patients showed no improvement; two gave evidence of slight improvement; and only two were completely relieved.

ILLUSTRATIVE CASES

CASE 1. The patient, a professional man, thirty-four years of age, came to the Clinic because of pain in the lumbar region with projection down both sciatic nerves. This pain had troubled him for one year and it was aggravated by walking. There was no history of injury. On examination, the lumbosacral spine was found to be rigid.

Lasègue's sign was positive on both sides. The Achilles-tendon reflexes were normal and there was no motor or sensory disturbance. Roentgenograms of the lumbosacral spine were negative.

When an attempt was made to obtain a specimen of fluid from the spinal canal through the fourth lumbar interspace, the procedure caused excruciating pain and the needle was then inserted in the third interspace without incident. The fluid gave a negative Wassermann reaction. The globulin test likewise was negative. The total-protein content was not determined.

Because of the intractable bilateral sciatic pain and the inability to obtain fluid through the fourth lumbar interspace, a diagnosis of tumor of the spinal cord (cauda equina) was made. On January 14, 1922, Dr. Adson performed a laminectomy and removed a protrusion of the fourth lumbar intervertebral disc (Fig. 8). The patient's convalescence was uneventful; he has been free from the sciatic pain since and has been in his office daily.

This patient was seen before routine determinations of the total protein of the spinal fluid were being made, and, therefore, we have no knowledge of this factor which might have been of great value in the diagnosis of this case. Likewise, today, this patient undoubtedly would have been subjected to study with lipiodol preliminary to laminectomy, for neurological examination in this case was negative for localizing signs. This is the first proved case of protruded intervertebral disc in which operation was performed at the Clinic.

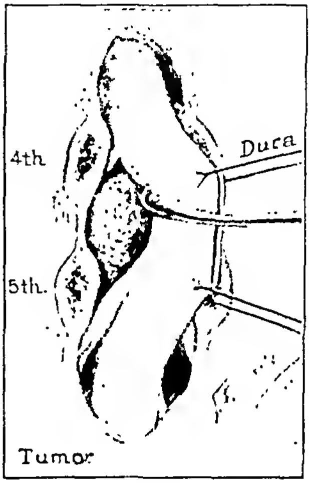

FIG. 8

Protruded fourth lumbar intervertebral disc producing bilateral sciatic pain. Removal of this protrusion resulted in complete relief from symptoms. (*Courtesy of Archives of Neurology and Psychiatry.*[4])

CASE 2. A man, thirty-five years old, came to the Clinic on November 4, 1935, because of pain in the left shoulder and left upper arm. He said that he had been in an automobile accident in 1932, at which time he had suffered dislocation of the left shoulder. For eleven months prior to registration he had experienced at first intermittent, and later constant, pain in the left shoulder with projection of pain along the upper extremity to the finger tips. Coughing, sneezing, and straining at stool aggravated the pain.

On examination, the patient was found to be well developed and well nourished. The neck motions were guarded. When the head and neck were inclined to the right or backward, the pain in the left upper extremity was increased. The muscles of his left upper extremity were slightly smaller than those of the right. The patient was right-handed and he had not considered the difference of significance. The deep reflexes in the left upper extremity were definitely increased over those of the opposite member. Sensation was normal. Numerous roentgenograms of the cervical spinal column, including stereoscopic views, were negative. On lumbar puncture, there was no subarachnoid block. The fluid was clear and contained seventy milligrams of total protein per 100 cubic centimeters, and the globulin test was positive.

Five cubic centimeters of lipiodol was then injected into the lumbar subarachnoid space for fluoroscopic study and the patient was examined on the tilting table. A partially obstructing lesion was demonstrated in the lower cervical region. Laminectomy was performed on November 14, 1935, at which time a protrusion of the disc between the seventh cervical and the first thoracic vertebrae was removed. This protrusion had

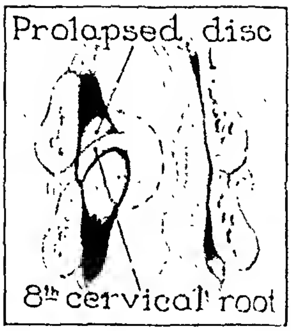

FIG. 9

Protrusion of seventh cervical intervertebral disc, showing stretching of nerve root and distortion of spinal cord.

occurred on the left side and the eighth cervical nerve was stretched over the cartilaginous protrusion (Fig. 9). The patient's convalescence was uneventful; he has remained free from pain and is back at his usual work.

This patient suffered intractable unilateral root pain. There was a history of injury, and the total protein was elevated. Lipiodol studies enabled us to make a diagnosis of intraspinal lesion and thus indicated the proper treatment, which was curative.

CASE 3. This patient, a white man of thirty-three years, registered at the Clinic on September 2, 1936, seeking relief from a chronic pain that was present in his back and which was projected down along the course of the right sciatic nerve. He stated that he had sprained his back four years before while lifting one end of an automobile. He had become so weak that he could not stand on his feet, and he had had recurrent attacks of pain ever since. Six months prior to registration he had begun to experience severe pain in the distribution of the right sciatic nerve. This pain was made worse by coughing, sneezing, and straining. The usual conservative treatment for low-back pain and sciatica had afforded little or no relief.

On examination at the Clinic, there was marked tenderness over the lower lumbar spine and over the right sacro-iliac joint. There was muscle wasting of the right thigh and leg. Lasègue's sign was positive on the right. The right Achilles-tendon reflex was diminished 50 per cent., whereas the left Achilles-tendon reflex was normal. Roentgenograms disclosed narrowing of the lumbosacral joint. On lumbar puncture, clear fluid, without subarachnoid block, was obtained. The total protein was seventy-five milligrams per 100 cubic centimeters and the globulin test was positive. On fluoroscopic study of the spinal canal with lipiodol, a persistent extradural defect opposite the lumbosacral disc on the right was detected (Fig. 10).

On September 9, 1936, laminectomy, consisting of the removal of the spines and a portion of the laminae of the fifth lumbar and first sacral vertebrae, was performed. A large extradural mass was found compressing the right fifth lumbar root. The nerve root was much enlarged as a result of oedema from compression. This mass, a protruded disc, was removed (Fig. 11). Convalescence was uneventful and the patient has been free from pain ever since.

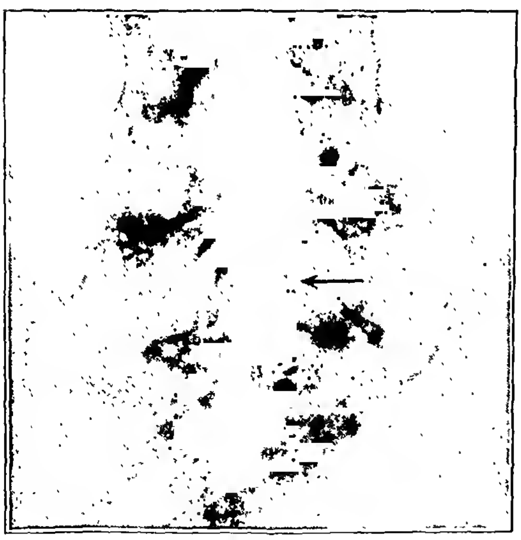

FIG. 10

Filling defect produced by a protrusion in the right anterolateral portion of the column of lipiodol opposite the fifth lumbar disc.

This case might be called a classic example of protrusion of a lumbar intervertebral disc,—that is, there was a history of injury or sprain involving the lower part of the back. Subsequently the pain had become more severe, and there was projection in one sciatic nerve. Examination of the spinal fluid disclosed an increased amount of total

protein, and fluoroscopic studies with lipiodol made possible a positive diagnosis of protrusion of the lumbosacral disc to the right side. The original roentgenograms disclosed narrowing of the lumbosacral disc, but this finding alone was not sufficient justification for assuming that the disc protruded into the spinal canal, for roentgenograms most often do not show any narrowing in cases of protrusion.

CASE 4. This patient, a woman twenty-eight years of age, was referred to the Clinic by her local physician because of intractable left sciatic pain of one year's duration. During the second stage of a difficult labor, she had complained of pain low in the back and shooting up the spine. One month post-partum, pain in the distribution of the left sciatic nerve made its appearance. The pain of which the patient complained was "cramping" and "shooting" and was aggravated by lying on the back and by walking. Coughing and sneezing likewise accentuated the discomfort. In the two weeks prior to her admission she had needed crutches in order to get around. Treatment elsewhere had consisted of heat, massage, diathermy, chiropractic adjustment, caudal analgesia, manipulation under anaesthesia, and application of a body cast for two months. Analgesic drugs also had been used without relief of the pain.

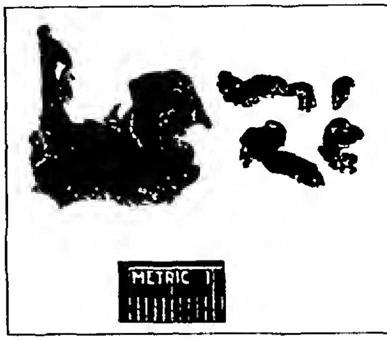

FIG. 11

Protruded portion of lumbosacral disc. The largest specimen popped out in one piece. The other tissue represents fragments of the same disc.

On examination, Lasègue's sign was positive on the left and there was slight exaggeration of the lumbosacral curve. Neurological examination was negative. Spinal fluid obtained on lumbar puncture was normal and contained twenty milligrams of total protein per 100 cubic centimeters. There was no evidence of subarachnoid block.

Roentgenograms of the thoracic and lumbar spine and of the pelvis were negative. No foci of infection were demonstrable. One of us (J. G. L.) was asked to see this patient in regard to further neurological investigation, for it was felt that we were not dealing with an ordinary type of sciatica. When 1-per-cent. procaine hydrochloride was injected into the caudal epidural space, the patient experienced excruciating pain in the distribution of the left sciatic nerve. A caudal lesion was, therefore, suspected and studies with lipiodol were advised, even though the total protein of the cerebrospinal fluid was only twenty milligrams per 100 cubic centimeters and neurological examination was negative. Fluoroscopic and roentgenographic examinations of the spinal subarachnoid space, after the intraspinal injection of five cubic centimeters of lipiodol, disclosed a persistent anterior extradural defect on the left, opposite the lumbosacral disc. At laminectomy on July 8, 1936, protrusion of the fifth lumbar disc was found (Fig. 12). The fifth lumbar root on the left was oedematous, owing to compression by the disc. Extradural removal of the protrusion of the disc was performed and the nerve root was thereby relieved of pressure.

Convalescence was uneventful, and the patient was dismissed from the hospital sixteen days after laminectomy and removal of the disc, free from pain and able to walk without assistance. She has remained free from pain.

Ordinarily one does not consider labor as likely to cause injury to the spine; yet observation of a patient in the second stage of a difficult labor will, we believe, convince anyone that the spine may be subjected to undue stress and strain during this "normal" act. The reverse Queckenstedt

test or epidural injection was the one procedure which led us to the correct solution of the problem involved in this case. In view of the negative neurological examination and the normal cerebrospinal fluid, we had little else to justify fluoroscopic studies with lipiodol.

CASE 5. This patient, a white man, first registered at the Clinic on September 20, 1921, at the age of twenty-five. He said that he had been in an accident in 1918 and had sustained fractures of the right arm and two ribs; he also received a laceration over the right eye. His chief complaint at the time of registration was numbness of the hands and feet, and he dated the onset of this condition as May 1921, at which time he had noted some numbness in the left hand. The numbness then spread to involve the right hand, forearm, and elbow. Involvement on the right side was more marked than that on the left. Shortly after the onset of this numbness, the right hand became weak, and later the fingers of the left hand also became weak. He likewise complained of pain between the shoulders, which was particularly noticeable in the evening.

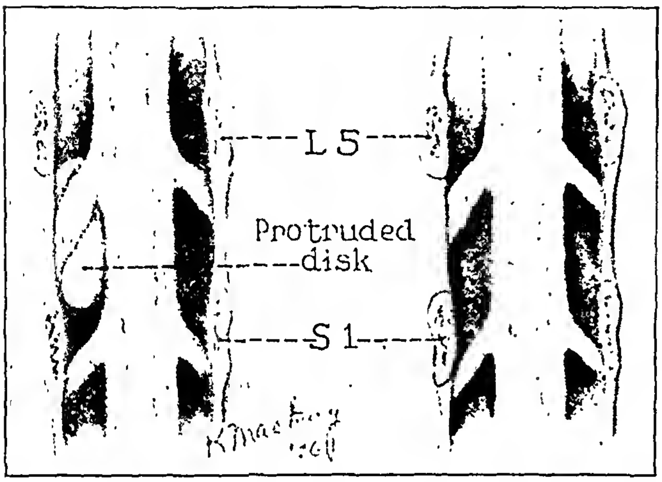

FIG. 12

Showing (left) unilateral protrusion of lumbosacral disc with oedema of compressed nerve root, and (right) nerve freed of pressure after removal of protrusion.

Neurological examination disclosed marked weakness of both right extremities and very slight weakness of the left extremities. Fibrillary twitchings were marked in the muscles of the right upper arm. There was a very slight disturbance of all qualities of sensation below the clavicles.

Cerebrospinal fluid obtained on lumbar puncture gave a negative Wassermann reaction and a positive globulin test, and there was one small lymphocyte per cubic millimeter of fluid. Total protein was not determined. There was no subarachnoid block. The patient was examined several times and many physicians saw him in consultation. The clinical picture was so unusual that this note was made: "Even on repeated examinations and going into the history the etiology of such a peculiar picture is unknown." The provisional diagnosis was myelitis with peripheral neuritis. Other lesions considered were syringomyelia and intramedullary neoplasm. Foci of infection were removed and the patient was advised to have a re-examination if he did not improve.

The patient returned to the Clinic on January 25, 1922, complaining of progression of all symptoms. Both lower extremities were spastic and ataxic, and the right upper extremity was also spastic. Bilateral Babinski reflexes were demonstrated. There was only a slight increase in the disturbance of sensation. The opinion at this time was that the patient had a progressive intramedullary lesion at the fifth or sixth cervical segment, probably a tumor or possibly a central gliosis. The findings were not typical for syringomyelia. On February 18, 1922, cervical laminectomy was performed by Dr. Adson and an anterior extradural cartilaginous tumor was removed. This tumor was attached to the intervertebral disc between the fifth and sixth cervical vertebrae. Following operation, the patient had an uneventful convalescence, and one month later there was marked subjective and objective improvement. He could use his hands more effectively, he walked better, sensation was practically normal, and both plantar reflexes were flexor. There was no sphincteric disturbance. The patient continued to improve and at present,

fifteen years later, he is working and earning his livelihood without any evidence of recurrence of the former trouble.

This is the case illustrated in Dr. Adson's article [1] on tumors of the spinal cord which was published in 1925. Prior to this operation, Dr. Adson had removed a protruded lumbar intervertebral disc in two other cases; in both cases operation was performed because of symptoms and signs suggesting a neoplasm of the cauda equina.

This patient, of course, should have been operated on at the time of his first visit to the Clinic, but diagnosis then was impossible, or at least it seemed to be. Today, when we are determining the total-protein content of the spinal fluid routinely in cases of suspected tumor of the spinal cord, this type of a case undoubtedly would be diagnosed earlier. No doubt the total protein was elevated in this case, and now fluoroscopic study of the spinal canal with lipiodol would be made.

RESULTS OF THE OPERATIVE REMOVAL OF PROTRUDED INTERVERTEBRAL DISCS

When an intervertebral disc is found to be protruded and is causing compression of one or more nerve roots or of the spinal cord, the surgical removal of that disc is followed by an excellent result in the great majority of cases. We have reason to believe also that this excellent immediate postoperative result will be permanent. We have in our series at the Clinic several patients who were operated on as long as fifteen years prior to this study and who have had no recurrence of their former symptoms.

In his article on chondroma of the intervertebral disc, Bucy [5] stated that there were two recurrences in one of Dr. Adson's cases. It is true that the patient to whom Bucy referred had recurrent symptoms which necessitated two subsequent laminectomies, but, after a very careful review of this patient's record and after discussing the case further with Dr. Adson, we are of the opinion that there was no true recurrence of the protruded disc. The secondary operations were essentially decompressive laminectomies for the removal of hypertrophied bone which was encroaching on the cauda equina [15]. At one of these subsequent laminectomies, Dr. Adson did remove some more disc tissue, but he felt that it was tissue that had been left behind originally, and he feels that the operation as we are now doing it will not result in recurrences. Then, too, owing to the fact that the condition is being recognized earlier, the operation is more easily performed and the results should be just as good or better than they have been in the past. In earlier cases in this series, patients were not operated on until more or less classic symptoms and signs of tumor of the spinal cord had developed. By this time the protrusion was large and very fibrous, and removal was difficult. If the condition is recognized during the stage of unilateral root pain, the protrusion is smaller and less fibrous, and its removal is relatively easy.

There has not been a postoperative death in this entire series, and this is all the more striking when one stops to consider that the surgical

removal of a protruded disc is at times much more difficult than is removal of a spinal-cord neoplasm. Also, the institution of drainage in the laminectomy wound is more often necessary in the case of a protruded disc, and one naturally would expect a slightly increased risk on this account.

There has been only one postoperative hemorrhage. This necessitated reopening the wound and the removal of an extradural hematoma. This patient made a complete recovery following this complication and has been entirely relieved of the sciatic pain for which the original operation was performed.

Of the fifty patients in this study, thirty-three have been completely relieved of the symptoms for which the operation was advised and performed. Fifteen have been benefited but not completely relieved, and two patients received no benefit from the operation.

The last two groups are very interesting and deserve further analysis. One of the patients who received no benefit from the operation was a woman, twenty-six years old, who was operated on in 1928 for protrusion of a disc between the sixth and seventh thoracic vertebrae. This patient had been paralyzed in the lower extremities and sphincters for two years prior to operation. There was a decubitus ulcer over the sacrum at the time of operation. At laminectomy, so much damage to the cord was apparent that little improvement could be expected. The disc was not removed but was decompressed. This patient died one and a half years later. The other patient who received no benefit from operation was a man, fifty years of age, who had had backache for twenty years, following an injury to his back, and recurrent sciatica for twelve years. During the neurological examination, it was recognized that this patient had a muscular dystrophy. Fibrillary twitchings were marked. Because of the increased total protein in the cerebrospinal fluid and the presence of a persistent defect in the subarachnoid column of lipiodol consistent with a protruded disc, laminectomy for removal of the disc was advised in the hope of thereby relieving the patient of his pain. At the time of laminectomy, the protruded disc was found to be very fibrous and its removal was difficult. The patient's convalescence was prolonged and, as has been said, he did not benefit by the operation.

Of the five patients who had protrusion of a cervical disc, all were relieved except one and this one has already shown marked improvement. This patient, a girl sixteen years of age, was totally disabled on admission and she was operated on too recently to tell what the ultimate result will be. She had spastic paraplegia with a sensory level at the first thoracic segment and had not walked for six weeks. She had slipped and fallen on the ice about five months prior to the onset of her symptoms, and there had been rather rapid progression of her condition for five months. On September 29, 1936, Dr. Craig removed a large protrusion of the sixth cervical disc, and the patient showed marked improvement. At the time of dismissal, she was able to walk. At operation, in this case, Dr. Craig noted marked compression of the cervical portion of the spinal cord and,

for that reason, he was conservative in his prognosis. The patient's progress to date, however, has been very gratifying.

Besides one case already described, there were four other cases of protruded discs in the thoracic region, in which the patients were not completely relieved. One of the patients was a man twenty-six years of age, who had been unable to walk for eight months, and after removal of the protruded disc there was only slight improvement. Another was a woman of sixty years, who was paralyzed from the waist down. Following removal of a protruded sixth thoracic disc, she obtained relief from the pain between the shoulders, but the paralysis persisted. She died six years later without evidence of further progression in the condition of the spinal cord. A man of fifty-two years had a protruding fifth thoracic disc removed in 1922, but the Brown-Séquard syndrome persisted after operation. This patient is still living.

Another patient, a man sixty-three years of age, came to the Clinic because of pain low in the back and abdomen with projection down the right leg. There was partial paralysis of the lower portion of the right leg. At operation, protrusion of the eleventh thoracic disc was demonstrated. The disc was not removed; instead, a decompressive operation was performed because of profuse bleeding during the course of exposure. This patient has shown marked improvement and is able to carry on his work.

There were ten patients in this series with protrusion of a lumbar disc, who, following operation, were benefited but were not completely relieved. One was a woman of forty years, whose disc was decompressed by laminectomy and removal of an adjacent facet. There was some improvement, but relief was not complete. This patient was of a nervous temperament and had a reactive depression following operation. Another patient in this group was the one with the questionable recurrence, in whose case two subsequent laminectomies were necessary because of hypertrophic osteoarthritis. A third patient, a woman of thirty-one years, who had had pain in the back and both lower extremities intermittently for six years, was definitely improved following removal of a protrusion from the fourth lumbar interspace; she still, however, has some sciatic pain.

The case of one patient, that of a man of forty years, presented a medicolegal problem. He had been struck in the back by a heavy piece of timber two years before registration, and he complained mostly of pain in the back. Roentgenograms disclosed a narrowed fourth lumbar disc. There was a congenital anomaly of the lumbosacral joint with slight anterior displacement of the fifth lumbar vertebra on the sacrum. This patient had previously undergone operative fusion of the lumbosacral joint and arthrodesis of the right sacro-iliac joint, without relief. Immediately following removal of a protruded fifth lumbar disc, the patient stated that he was free from pain, and he walked without the support of the cane which he had used prior to laminectomy. At the end of two months, however, he returned to the Clinic and said his back bothered him, and later he resumed the use of his cane.

A man of fifty years has been markedly relieved by operation, but he still complains of aching in the backs of the thighs. Another patient, a man of forty-five years, was relieved of sciatic pain but has some low-back pain unless he wears a sacro-iliac belt. Prior to operation, this support had not afforded relief. Another patient, a man of fifty-four years, had had pain in the back with recurrent bilateral sciatic pain for twenty-four years. Roentgenograms disclosed narrowing of the lumbosacral disc. It did not seem that his symptoms were on a neurological basis. However, five days following a bone-graft operation for fusion of the lumbosacral joint, there was evidence of a complete transverse lesion of the cauda equina below the level of the fifth lumbar nerves. A protruded lumbosacral disc was demonstrated on study with lipiodol. Unilateral laminectomy, without removal of the protruded disc, was performed. The operation was very difficult, owing to the presence of the recently placed bone graft which was not disturbed. There has been some improvement, but not complete relief.

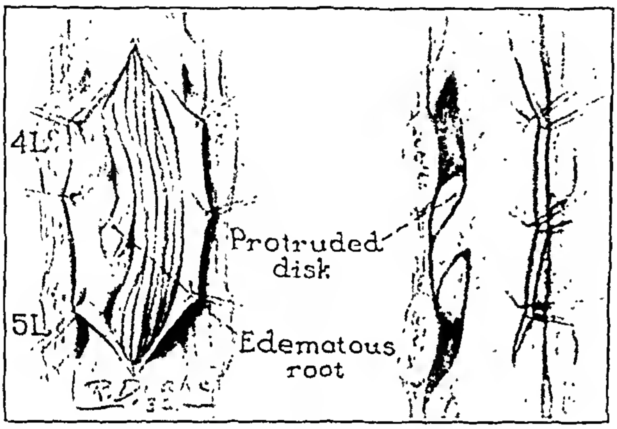

Fig. 13

Unilateral protrusion of fourth lumbar disc with marked oedema of fourth lumbar nerve on the left.

A woman of thirty-one years came to the Clinic with severe soreness across the sacrum, pain down the right leg, paraplegia, saddle anaesthesia, and loss of sphincteric control. A protruded fourth lumbar disc was removed, with very gratifying results. There was almost immediate improvement in power and in sensation. The patient was able to walk without assistance and she could empty her bladder. She still, however, has some pain on sitting.

A man of fifty-two years had had recurrent attacks of left sciatic pain for five years. All of the usual, and some of the more recent, methods of treatment had been employed, without benefit. At the time of operation, one of the largest specimens of protruding disc in our collection was removed from the fourth lumbar disc. This protrusion was removed extradurally from under the fourth lumbar root on the left. The root was very oedematous as a result of compression by the disc (Fig. 13). The arachnoid and dura mater were adherent over the dome of the bulging disc. There was immediate and complete relief from symptoms; however, we have recently learned that this patient is having some pain in the leg.

The last patient in this group was a man of forty-one years, who, in addition to low-back and sciatic pain, had symptoms and signs of spondylitis. Studies with lipiodol disclosed protrusion of the fourth lumbar

disc into the spinal canal. It was appreciated that removal of the disc would not cause disappearance of all the symptoms and, after the problem had been explained to the patient, laminectomy, with removal of the protruded portion of the disc, was performed. Much to our surprise, all of the patient's symptoms disappeared following operation. Two months later, however, he began to complain of pain in the back and of a feeling of tightness in both legs, which undoubtedly was an expression of activity of the spondylitis.

SUMMARY AND CONCLUSIONS

In a series of fifty consecutive cases in which laminectomy for removal or decompression of a protruded intervertebral disc has been performed at The Mayo Clinic, the results have been very gratifying. These patients were selected from a large number of individuals who came to the Clinic with various types of chronic pain. For the most part the pain resembled that which results when a spinal-nerve root is compressed.

There was not a postoperative death in the series.

Protrusion of an intervertebral disc is a definite anatomical and pathological condition. It is usually the result of trauma which may be slight or severe. The most common symptom of such protrusion is pain along the course of one or more spinal nerves, most often the sciatic nerve.

The diagnosis is made by roentgenographic examination of the spinal canal after the introduction of a radiopaque oil into the subarachnoid space. The treatment of choice is laminectomy, with removal of the protruded portion of the disc. Decompressive operations without removal of the disc are not advised.

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THE COMPENSATION ASPECTS OF LOW-BACK CONDITIONS*

BY HOWARD L. PRINCE, M.D., ROCHESTER, NEW YORK

The present status of these back problems, as far as the insurance companies are concerned, is not flattering. It may be summed up in a quotation from a letter received last month from the surgical head of one of our largest insurance companies: "With the difference in the compensation laws in the various states, it is difficult to evaluate our final results but it does seem as though, in the treatment of these injured backs, we are no nearer a solution than we were a number of years ago." The head of another large company says: "I am free to admit that we are often undecided as to the proper course to pursue in these back cases. As a matter of fact, in 75 per cent. of these cases, we compromise without resorting to any operative procedure and settle them for a lump sum." I should say that they are bewildered by the multiplicity of ideas about back conditions held by the medical profession. Again quoting: "One of the greatest difficulties with which we have to deal is to obtain a correct diagnosis. In a number of instances these industrial cases are examined and reported upon by outstanding specialists and we are confronted with reports in regard to the conditions found and proposed treatment, often surgical, completely at variance one with the other." Quoting from another company: "A great many methods of treatment have been used in compensation cases, none of which, apparently, so far as relief is concerned, has accomplished its purpose. One method of treatment is just as good as another—it would appear that there is no choice."

I believe that the crux of the difficulty lies in the fact that every case presents a combination of factors—psychological and anatomical. Not until both factors are given due and proper consideration are we going to achieve much better results than we have to date.

The compensation case is often influenced by racial traits which we cannot change and about the handling of which we know little, by marital conditions, and, particularly, by economic conditions. Think of the strain on an injured man's ethics during the past seven years when to get well meant to give up compensation and become jobless! We all saw how hard it was to get the better placed individual off a paying accident policy.

Doctors talk about traumatic neuroses in these back cases. John Doe stoops to lift a box and gets a catch in his back. For weeks, months, years he is afflicted by steady pain—severe enough to prevent working but not bad enough to keep him from gaining weight and looking hale and hearty while he draws fifteen or twenty dollars a week. He gradually develops quiverings and twitchings and a woebegone look when he is at

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hearings. Dumb as he is, he learns that, on examination, certain activities on the part of the examiner call for certain responses on his part. He can always find a doctor who will agree that, while objective symptoms are lacking and it is curious that so slight an injury should cause so long a period of disability, he is unable to return to work. He has a traumatic neurosis. If the question of the possible effect of the fifteen or twenty dollars per week is brought up as a factor in this neurosis, it is brushed aside as being of no moment,—it is probably just a capitalistic myth.

Compensation laws are rightfully designed to protect the claimant and he should have the benefit of the doubt, but his advantage may become too great when a lay commissioner has the final decision as to whether the claimant is disabled.

If employers could and would help us in handling these back cases, some gain would be made. Small employers often cannot and large employers often will not take these men back at light work—that is, work requiring little strain on the back—for a period of several weeks and then let them gradually get hardened again. This, in many cases, would be a helpful procedure.

It is with some feeling of hesitancy that I come before this group to discuss problems in regard to low-back conditions. This Academy does not represent a cross-section of Medicine,—it certainly considers itself the cream off the top. Yet I dare believe that a given case could be presented to this Academy and as many different diagnoses and corresponding methods of treatment would be suggested as there are groups allied by training in the Academy. The development of our present knowledge of the low back is interesting. I have lived through most of it. The hypothesis of sacro-iliac strains and displacements was the gleaming star leading its disciples onward and upward. This was so in Boston, to a lesser extent in Baltimore, and with diminuendo effect in Philadelphia, New York, and Chicago; it disappeared entirely in Toronto and Montreal. It puzzled me as to how sacro-iliac subluxations could be so generally believed in in Boston and Baltimore, and not be accredited in New York and Chicago. I saw them manipulated in Boston with due regard to what the roentgenogram showed. In Baltimore, with equal enthusiasm, the surgeons manipulated all cases in the same manner. In practice I was struck with the uncertainty of results and wondered if there might not be mistakes in diagnoses. About sixteen years ago, it was our good fortune to have the Interurban Orthopaedic Club meet in Rochester and, within three minutes, I was shown a roentgenographic demonstration of sacro-iliac subluxation on the left side of the pelvis by a Bostonian, and a sacro-iliac subluxation on the right side of the same pelvis in the same roentgenogram, by a distinguished gentleman from Baltimore. This rather confirmed my growing doubts as to the certainty of our knowledge about sacro-iliac lesions. Now sixteen years have passed and, during this time, great advances in diagnosis and treat-

ment have been made. Much has been contributed to the anatomical knowledge of the lower back; perhaps more to the theoretical possibilities of treatment. With the development of these ideas, emphasis has been placed on surgery as well as on various other methods. Among the many forms of treatment which have been suggested are: epidural injections of saline or of novocain used in certain parts of the country; fusion of the sacro-iliac joint by various techniques—each and every modification vouched for by its parent; fusion of the lumbosacral region by the Hibbs or Albee technique, with various additions by equally enthusiastic parents; fasciotomy; and now spinal exploration for extrusion of the intervertebral discs.

Still the insurance companies are in trouble, as shown by the following quotation: "For instance, we may have a diagnosis of a sacro-iliac condition. The surgical treatment proposed is stabilization of the sacro-iliac joint. On the same case another surgeon makes a diagnosis of a ruptured intervertebral disc and the treatment suggested is an operation on this disc. We have half a dozen cases, in various parts of the country, where a diagnosis has been made of a ruptured intervertebral disc following lipiodol injection into the spinal canal. We have cases where such a diagnosis was made and operations were performed by some of the finest neurological surgeons in the country, and the condition diagnosed was not found. In one of these cases a stabilization operation on the lumbosacral joint was performed in 1934 and the man is still disabled. In another instance, in one of the big clinics of the country, diagnosis of a lumbosacral condition was made and lumbosacral stabilization was performed. Symptoms persisted following the operation; diagnosis of a ruptured intervertebral disc was then made. Operation was performed and such a condition found. The end result is not yet known. In another case, in an Eastern state, two outstanding orthopaedic surgeons examined a man; one suggested a stabilization operation for the sacro-iliac joint and the other advised an operation for a ruptured intervertebral disc. These diagnoses were made within a day or two of each other."

I think it has long been recognized that, with rare exceptions, it is not good judgment to go to the parents of the child to find out the child's faults. The mental parent of an operative procedure is liable to have a biased opinion of its value, especially if it is taken outside its home circle.

Recently I have had opportunity to study the end results of a fairly sizable group of cases recorded by one insurance company. Of six cases of sacro-iliac fusion in which the results were classed as fair, one case is not yet settled. This patient has been disabled for four years following the operation and for six years after the injury. The other five cases were finally settled with an average permanent disability of 73 per cent. after periods varying from four to ten years. There were eight cases of lumbosacral fusion in which the results were called fair: these were settled with an average permanent partial disability of 51 per cent. In five cases of sacro-iliac fusion the results were classed as poor. One

patient died; three are still disabled after an average period of eight years; and the remaining patient is now considered to have a fair result. There were seven lumbosacral fusions with poor results; these cases were settled with an average permanent disability of 84 per cent. In seven cases of lumbosacral fusion by the method of Hibbs good results were obtained; five patients returned to work in an average of nine months postoperatively. There were twenty cases the results of which were classified as good, fair, and poor, but, when analyzed, it was found that two patients had no permanent disability; six were given 10 per cent. permanent disability; one was given 5 per cent. permanent partial disability; and the remaining eleven cases were settled with a permanent partial disability averaging 40 per cent. In these cases the operations were performed by experienced surgeons,—probably most of them were members of this organization or of similar ones, and it is this sort of an experience which leads to the following quotation: "Following an observation of fifteen years in the diagnosis and treatment of low-back conditions, it is our opinion that, with a few exceptions, conservative treatment has shown better results than operative treatment." Why should this be? Either our knowledge of anatomy is faulty, or our interpretation of its indications is wrong, or else we have taken the intangibles, mentioned earlier, into too little consideration.

It seems to me that, at the present time, the question of injury to the disc with extrusion of part of it into the spinal canal is very important, but there are serious questions to be answered before the rank and file of surgeons adopt it. First, what effect will four or five cubic centimeters of lipiodol have if left in the spinal canal? I have asked a number of neurologists and they do not know. Second, can these extruded parts be removed without leaving a weak back? There is little advantage to the claimant or to the insurance company if a brilliant operation is done and the claimant is no more able to do active work than he was before. These questions cannot yet be answered.

I feel sure that there are certain members of the profession, who, because they are selecting their cases with great care after a careful diagnosis, and because they are skillful operators, can solve some of these back problems satisfactorily. However, having listened for many years to papers on low-back conditions and having read others, I find myself in the position so well expressed by Omar Khayyam: "Myself when young did eagerly frequent doctor and saint, and heard great argument about it and about; but evermore came out by the same door as in I went."

It is upon the first medical man who sees the injured back that much of the responsibility for the after-results falls. I believe that all of these backs should be rested. Frightening the individual or fixing in his mind the idea that he has a serious back injury should be meticulously avoided. Strapping the back and urging the patient to return to work as soon as possible are, I believe, the causes of much of our difficulty in later cases, in spite of the statement of the head of one of the insurance companies

that he is impressed by the better results that osteopaths obtain because they minimize the condition and do not frighten the injured man into feeling that he has a serious lesion. Strapping and a few days' rest on a hard bed with the application of a little local heat—perhaps relaxing the patient completely with morphine for the first forty-eight hours—will enable the patient to get back to work when he feels that he can. He has a feeling of having been well cared for and his inclination is to return to work. The psychological character of the individual, as well as his physical condition, should be taken into consideration in every case. If the injury has occurred to a spine already showing the ravages of hypertrophic arthritis, due consideration to that fact must be given. In compensation cases, I am continually struck by the importance of keeping the attitude of the patient right. The doctor may not be able to do this; fancied injustices on the part of the employer may make it very difficult.

The application of casts and the use of braces, I believe, are fraught with peril. Certainly before employing either form of treatment, one should be very sure that the advantages to be gained will outweigh the possible harmful effects on the patient. It is always well to look back and realize that casts and braces, which were believed in so thoroughly by the older generation, have, in most instances, failed to accomplish what they were supposed to have done. I often think of the situation in regard to scoliosis,—men wrote books on the treatment and cure of scoliosis, illustrating plaster jackets and braces that pressed here and pulled there, but, on final investigation, no case of cure was shown.

When it comes to the question of the need or the advantage of surgery in low-back conditions, we should deliberate most carefully, because, if we give certain types of individuals a scar, they will never get out of the compensation class.

LOW-BACK LESIONS

Closing Remarks by the Chairman*

BY JOEL E. GOLDTHWAIT, M.D., BOSTON, MASSACHUSETTS

A symposium of this type, dealing with a symptom which is probably the most common that is met by the physician, naturally should lead to the consideration of the subject in the broadest possible manner.

In the first place, it should be recognized that backache usually means strain of the joints of the back with, at times, so much pressure upon the nerve roots that referred pain results. In such a discussion, all conditions which might contribute to symptoms of this type should be considered and, representing the gynecological point of view, Dr. Frank H. Pemberton, Professor of Gynecology at the Harvard Medical School, has written stating that backache due to purely gynecological conditions is relatively rare. A similar statement has been received from Dr. Edward L. Young, representing the urological point of view. It is apparent, therefore, that, while the diseased conditions of the pelvic organs or of the genito-urinary tract in men or in women may at times be associated with backache, usually in these cases the other symptoms are so conspicuous that there is very little question as to the main source of the difficulty.

In any discussion of the subject of backache, naturally the first consideration should be the structure of the spine itself, especially with reference to the low back. A study of comparative anatomy shows that the number of vertebrae in the lumbar region, as seen in the lower orders, varies considerably from the many lumbar vertebrae in certain orders to the few in others, and that these changes occur at the thoracolumbar level or at the lumbosacral level. Since this is the case, variations in the shape of the bones, as well as in the number of the vertebrae in the lumbar region, should be more or less expected in the human spine. These anatomical variations are many times of much importance in the production of symptoms, as well as in the treatment required to give relief. Too much attention or care cannot be given to this phase of the difficulty before starting upon any course of treatment in the individual case. We are very fortunate in having this aspect of the subject presented by Dr. Willis.

It should be remembered that these anatomical peculiarities have existed since birth, but, as a rule, the individual seeks treatment in the adult periods, which means that the anatomical peculiarities are probably only part of the problem. In considering the elements which make them a special source of difficulty, probably the most common is the imperfect use of the body, so that the weight-bearing points in the low back are abnormal. In practically all such cases, the lumbar spine, especially at the

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lumbosacral level, is used in the position of extreme extension—a position which is one of strain under the best conditions—and if anatomical peculiarities exist, the development of symptoms should not be a matter of surprise. Therefore, once the anatomy is understood, there should be insistence on the improvement of the mechanics of the region, so that the best possible function may be expected. In the consideration of this aspect of the difficulty, we are fortunate in having Dr. Brown present the subject.

At times the anatomical peculiarities are such, and the joint strains have existed for so long, that surgery, with the idea of fusing one or more of the joints, becomes necessary and we are fortunate in having Dr. Compere present this phase of the problem. With reference to this it should always be remembered that, if it becomes necessary for one joint to be fused, some other joint is obliged to take up the work which that joint formerly performed, and it should be appreciated that the joint which has the added strain put upon it may many times cause as much difficulty as was previously present.

The chief point that seems to me important with reference to surgery of the spine, or to fusions of the joints, is to be perfectly sure that the lumbar spine is flattened, or that the joints are in the position midway between full extension and full flexion. In this position the muscle balance will not be disturbed and there is more likelihood of obtaining excellent end results. To fuse until this has been accomplished means fusing the spine in a deformed position and the last state of the individual may be worse or no better than the first.

In connection with the fusion, it should be remembered that probably there are very few in this room who have not had more or less backache, but probably few, if any, have felt it necessary to have the back fused because of this.

Another feature which is a definite part of such a symposium is a condition which has received general recognition only comparatively recently, but which was described by the Chairman a good many years ago,—namely, the backward displacement of the intervertebral disc, or the nucleus pulposus. As the result of Schmorl's work, this has received renewed attention. In considering this feature of the back problem, it should be recognized that always when the nucleus pulposus is squeezed backward the lumbar spine, especially at the lumbosacral joint and the joint above, has been used with the bones in the position of extreme extension. This narrows the space between the vertebrae at the back, and the nucleus pulposus is, apparently, squeezed, with the result that it breaks through the posterior portion of the controlling ligament. It should be appreciated that this ligament which holds the nucleus pulposus in its proper shape is much thinner in the posterior part in front of the spinal canal than around the sides and front. This naturally means that, if the nucleus pulposus is compressed, the weakest place for it to squeeze through will be at the back.

In operating with the idea either of removing the displaced portion or of simply doing a laminectomy and relieving the pressure by taking away the arch of the bone, it should be remembered that many times the articular processes are so placed that they project over the spinal canal, especially at the lumbosacral level, with the result that, even though a laminectomy is performed, it does not necessarily relieve the pressure of the extruded portion of the intervertebral disc at the sides. For this reason, in this type of case, as well as in the cases in which fusion is to be done, the lumbar spine should be flattened so that there is the least abnormal compression upon the intervertebral disc tending to crowd the nucleus pulposus out of place. Undoubtedly, some of the disappointing results of operation in cases in which this condition has existed are to be explained in this way. We are fortunate in having the surgery of this condition so ably presented by Dr. Love.

The subject of acute back strains or injuries, including the industrial accidents and compensation features, has been presented by Dr. Prince in a way that should cause us all to appreciate how serious this phase of our work is, and how unsatisfactory much of the treatment of these cases has become. It seems to me that the most important thing for us to realize is that most of these cases represent a joint sprain and that the lumbosacral and the sacro-iliac joints are most commonly affected. Because of the structure of these joints, it is, of course, extremely difficult to protect or to fix them with the patient up and about. The result is that, as most of these cases are handled at the present time—either comparatively little attention is given in the early stages or treatment consists merely of strapping the back or administering drugs—the congestion of the part incidental to the sprain is continued, and, instead of an acute sprain, in a comparatively short time a chronic condition results. Once such a condition develops and the compensation features are added, with the many examinations that are involved, it is easy to understand how unsatisfactory the treatment and handling of these cases is, irrespective of the method.

As has been suggested by Dr. Prince, if such cases could be treated as any other acute sprain is treated—namely, with protection for a few days, long enough for the acute congestion to subside, and then a few days longer for the healing of the ligament to occur—most of these patients would return to their ordinary activities in a comparatively short time. Since it is almost impossible to use any form of support that will satisfactorily protect these joints when the patients are up and about, it seems to me, as it apparently does to Dr. Prince, that these patients should be put to bed for a week or ten days, with any form of local application to the low back that will stimulate the circulation, and with the expectation of a rapid recovery and the ability to return to work in a comparatively short time. It should be stated to such patients that there will undoubtedly be some backache or back pain for a short time, as would be expected in treating any other sprained joint. With such handling, it seems to me

that most of these cases become simple, and they do not present the difficult type of problem, or call forth reproach, as they certainly do in the minds of Compensation Boards at the present time.

As a whole, it should be recognized that low-back pain is common, and that simple manipulations often relieve the symptoms but rarely ever cure them. It should also be recognized that operations many times relieve pain, but, unless they are performed with the full appreciation of the anatomical structure and the mechanics of the back, the end results are disappointing. On the other hand, if all of the features which have been presented in this symposium are considered, probably fewer of the cases will be operated upon and the treatment of these cases as a whole will represent a greater credit to our profession than they do at the present time.

MULTIPLE EPIPHYSEAL ANOMALIES IN THE HANDS OF A PATIENT WITH LEGG-PERTHES' DISEASE

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The etiology of osteochondritis deformans juvenilis (Legg-Perthes' disease) is not established. The theories to explain its occurrence are not accepted by all. The epiphyseal system in individuals with the disease, therefore, deserves study and the finding of multiple rare anomalies of epiphyses of such individuals deserves reporting.

CASE HISTORY

A. C., male, aged nine years, the child of Greek parents, was first seen in the Out-Patient Department on May 2, 1934. A diagnosis of osteochondritis deformans juvenilis was made from the history, the physical examination, and the roentgenograms. The patient was advised to wear a hip spica cast and to stay in bed.

He was next seen on November 2, 1934. At this time he reported that he had worn the cast only three months after which he had been up and about. The symptoms had returned. He was admitted to the University Clinics and has been kept under observation since that time. The lesion has healed and the patient is now ambulatory, without a limp.

During a roentgenographic study of the carpal bones of grossly normal hands, anomalies of the hand skeleton were found in this patient. Subsequently, the rest of the skeleton was x-rayed and found to be roentgenographically negative except for the diseased right hip. The patient is left-handed and the two hands appear entirely normal except for a medial deviation of the distal phalanx of both index fingers of about 30 degrees (Fig. 1). The anomalies found, as illustrated in Figure 2, include:

1. Double ossification center for os lunate, bilateral.
2. Distal epiphysis of first metacarpal with partial fusion to the diaphysis, bilateral.
3. Proximal epiphysis of second metacarpal with beginning fusion to the diaphysis, bilateral.

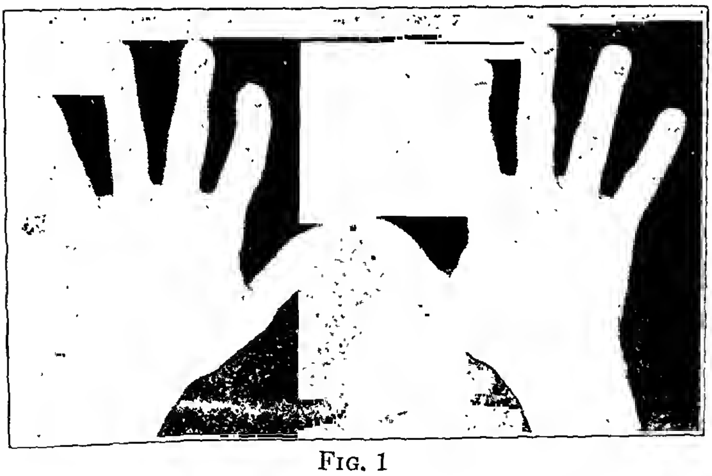

FIG. 1

4. Suggestion of fused proximal epiphysis on fifth metacarpal, bilateral.
5. Distal epiphysis on all the first row of phalanges and on the second to fifth inclusive of the second row.
6. Growth

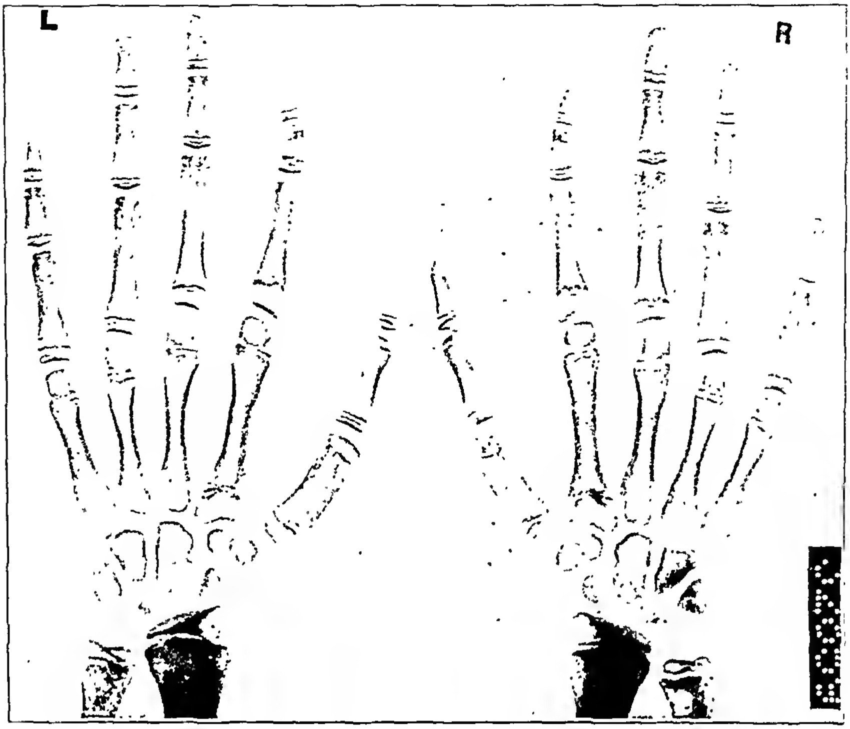

FIG. 2

arrest on the medial side of the distal epiphysis of the second phalanx of the index finger with resultant medial bowing of the finger, bilateral.

The double ossification center for the lunate represents two distinct bones. The accessory bone is definitely not the anomalous so-called "os centralis" which is described by Gray and others as lying between the lesser multangular, capitate, and navicular, for in this case the bone is distinctly in the position of the lunate, lying either above or below it. Carter speaks of an epilunate, or hypolunate, but in this case the accessory bone is as large as the lunate itself, so that it is impossible to state which is the normal bone and which one is the accessory. Roentgenograms at a later date may clarify this point. This duplication of the lunate bone is so uncommon that there are no statistics showing its incidence.

A distal epiphysis on the first metacarpal appears in about 40 to 50 per cent. of male children in the group ranging from eight to eleven years of age and less commonly in females.[1, 3]

A proximal epiphysis on the second metacarpal is present in a small percentage of normal children. Carter reports the incidence of from 1 to 2 per cent. On the fifth metacarpal it is less common.

Epiphyses on the distal ends of the first and second rows of phalanges are also uncommon. Most writers do not even mention this anomaly.

From a study of 2,700 roentgenograms of the hand, Stettner tabulated the number of anomalous epiphyses which he found in the metacarpals and phalanges as follows:

Location		*Cases*
Metacarpal	II	434
"	III	37
"	IV	22
"	V	168
First Phalanx	I	24
" "	II	5
" "	III	10
" "	IV	11
" "	V	8
Second Phalanx	II	6
" "	III	6
" "	IV	29
" "	V	128

These figures are considerably higher than those of most authors, probably because they included a number of cases with multiple congenital defects and anomalies.

The fact that a large number of these anomalies (fourteen in each hand) were found bilaterally in an individual with osteochondritis deformans juvenilis may justify this case report. Perhaps this disease is dependent upon some congenital abnormality of the epiphyseal system as this case might suggest.

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PRIMARY CARCINOMA OF THE LIVER WITH METASTASIS TO BONE

Report of a Case

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Primary carcinoma of the liver is seen quite infrequently. This lesion with metastasis to bone has seldom been described.

According to Boyce and McFetridge, something over 600 cases of primary carcinoma of the liver have been reported. Their cases (144) represented approximately 2 per cent. of more than 65,000 autopsies. Seven cases of metastasis of this lesion to bone have been reported by Blumberg, Schmidt, Catsaras, Kaufmann, and Moon. Geschickter and Copeland, in their complete description of bone tumors, report one case of carcinoma of the liver with bone metastasis.

Of interest from its clinical and pathological aspects, the case reported here also presented an unusual surgical picture. At operation, the metastatic lesion was found to have invaded bone at each side of the involved joint.

FIG. 1

Showing destructive lesion of right sacro-iliac joint.

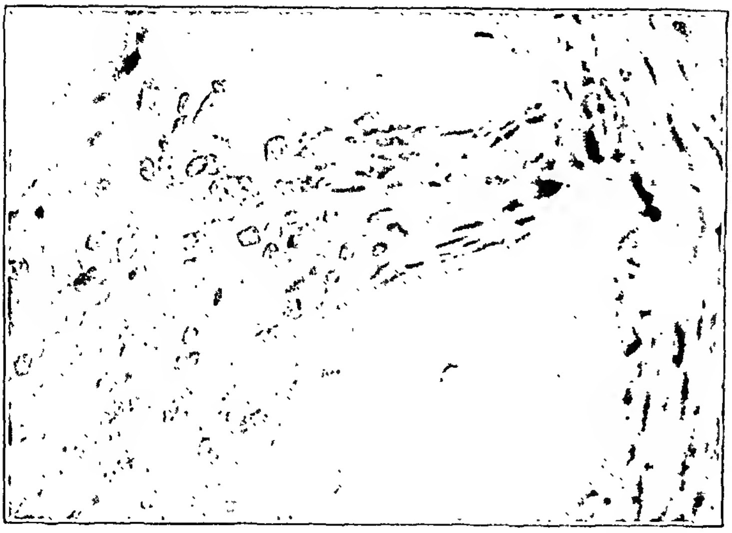

Fig. 2

Metastatic-carcinoma cells invading bone in the sacro-iliac region.

CASE REPORT

A. S. (No. 28412), a male, fifty-eight years of age, came to the Orthopaedic Clinic of the Henry Ford Hospital on May 15, 1935, complaining of low-back pain and pain in the right hip of two years' duration. Treatment had included mineral baths, injection of the sciatic nerve, and vasectomy. Walking was possible only with a cane. Weight loss was denied.

Examination revealed an emaciated adult male. The lumbar spine was flat. Flexion of the spine was made freely and without muscle spasm. Extension was limited. Pain on palpation was present over the right sciatic exit. None was found over the lumbar spine. The right hip resisted passive internal rotation. Abduction of the hip was limited to 5 or 10 degrees, but adduction was normal. Flexion was possible to 80 degrees, but extension was painful. There was pain on pressure over the course of the right sciatic nerve. Reflexes were equal and active. No sensory disturbance was found.

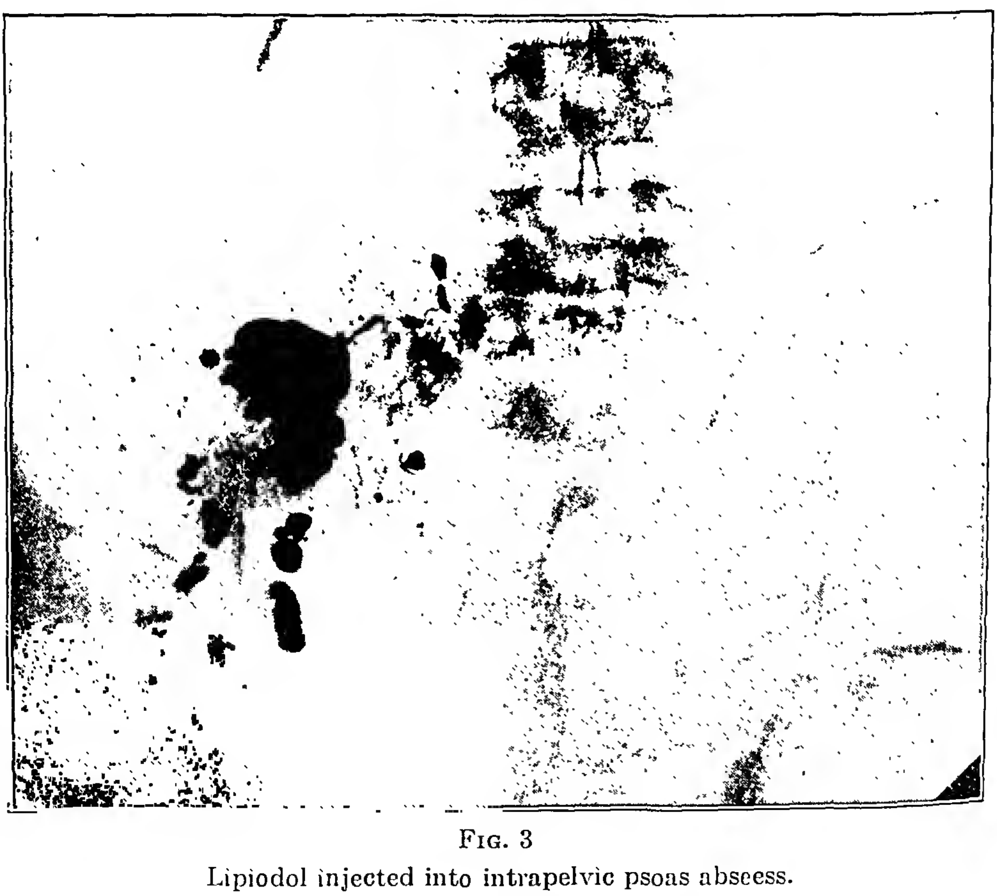

Fig. 3

Lipiodol injected into intrapelvic psoas abscess.

The legs were equal in length and no unilateral atrophy was found. The examination suggested disease of the hip joint rather than of the spine.

Roentgenographic examination (Fig. 1) showed a destructive lesion which involved the inferior part of the right sacro-iliac articulation. No abnormality was found in films taken of the hip.

We were unable to differentiate between malignancy and tuberculosis, and advised exploration, biopsy, and frozen section. If tuberculosis were found, fusion was advised.

On June 12, 1935, the right sacro-iliac region was exposed through a curved incision and the joint proper was exposed by lifting off the posterior superior spine of the ilium. No purulent material was encountered, but in the lower third of the joint an area, yellowish in color and somewhat friable in structure, invaded the bone of the ilium as well as the sacrum. As much of this as possible was removed by curette and gouge.

FIG. 4

Sectioned liver, showing primary carcinoma.

The postoperative course was uneventful until June 17, 1935, when the patient got out of bed without permission. The operative wound became exposed at this time. The sutures were removed ten days following operation and a small amount of purulent material was found. Culture of this material showed staphylococcus albus. The patient's strength increased for a month, when discomfort in the right leg recurred. By this time the wound had healed except for two small draining sinuses.

The biopsy material was eventually decalcified and sections were described by the pathologist as showing "large irregular cells with pink-staining cytoplasm and large, vesicular, stippled nuclei. Many mitotic figures are seen. These cells are invading the intertrabecular spaces of the bone in solid sheets rather than replacing the bone." (See Figure 2.) A diagnosis of metastatic carcinoma was made.

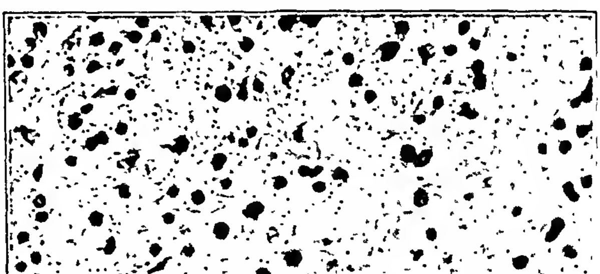

FIG. 5

Liver tissue at periphery of nodule invaded by carcinoma cells.

Because of the discomfort in the right leg, absolute alcohol was injected into the subarachnoid space by the neurosurgeon on November 26, 1935, and again on December 19, 1935. Relief was transitory. No evidence of a primary tumor could be found. One dose of deep x-ray therapy was given.

Three sinuses persisted. On March 18, 1936, roentgenograms, taken following injection

of the sinuses with lipiodol, revealed an apparent intrapelvic psoas abscess (Fig. 3). The patient's condition grew progressively worse. On April 22, 1936, he had a series of acute abdominal pains which increased in severity until he finally expired with clonic convulsions on April 26, 1936.

Necropsy showed a large abscess in the body of the right psoas muscle. A terminal bronchopenumonia was present. In the dome of the right lobe of the liver was a small firm mass, three centimeters in diameter, which was sharply circumscribed. (See Figure 4.) This mass was densely adherent to, but did not invade, the diaphragm. At the center was a fibrous core from which fibrous strands radiated. Multiple incisions throughout the remainder of the liver revealed no similar nodules.

Microscopic sections of this nodule showed it to be composed mainly of fibrous connective tissue which had undergone extensive hyalinization. In the periphery of the mass were seen a number of neoplastic cells which infiltrated the surrounding liver parenchyma (Fig. 5). These cells were large and had bizarre nuclei which were often hyperchromatic. Occasional mitotic figures were noted. The malignant cells in some areas had a signet-ring appearance and some showed one or more definitely enlarged nuclei. The central portion of the nodule was entirely fibrous, while the peripheral portion showed a moderate number of neoplastic cells.

Microscopic section of tissue from the region of the secondary involvement showed neoplastic cells similar to those described, arranged in small accumulations. Here, there was some suggestion of an adenomatous arrangement. Marked fibrosis had again taken place throughout this area.

Final anatomical diagnosis: Primary carcinoma of liver (bile ducts) with metastatic carcinoma of the right sacro-iliac joint and surrounding tissue.

The diagnostic difficulties and the fact that the metastatic lesion involved and crossed the sacro-iliac joint to invade both the sacrum and the ilium make this case unique.

The author wishes to acknowledge the work of Mr. Neill Graham in the preparation of the photomicrographs used in this article.

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THE TREATMENT OF FLAT-FOOT BY MEANS OF EXERCISE

BY ERNST BETTMANN, M.D., LEIPZIG, GERMANY

The human foot was originally an organ for gripping. Our forefathers had a capacity for walking and climbing which most of us no longer possess. Nowadays, due to the wearing of shoes which cramp the feet and walking on hard pavements, the foot often becomes painful and inadequate to perform its function. In the treatment of flat-foot, exercise is of equal importance with, if not of more importance than, the mechanical supports which are too generally sold to cure individual cases. The purpose of medical exercises is the systematic strengthening of the lifting muscles on the inner border and transverse portion of the arch,—tibialis anterior, tibialis posterior, flexor hallucis longus, flexor digitorum longus, interossei, and peroneus longus. If the foot muscles functioned properly, they would prevent the painful lowering of the arch, and mechanical support would often be unnecessary.

There are two types of gymnastics which may be employed to correct flat-foot:

1. A series of foot exercises which can be supervised by the wise mother, the nurse, or the family doctor.
2. Exercises by means of special apparatus, which permit the amount of the exercise to be increased as much as is necessary for the gradual strengthening of the weak muscles.

EXERCISES

Concerning the first type, the author suggests the following simple foot exercises which may already be known:

FIG. 1-A

Exercise with the medicine ball.

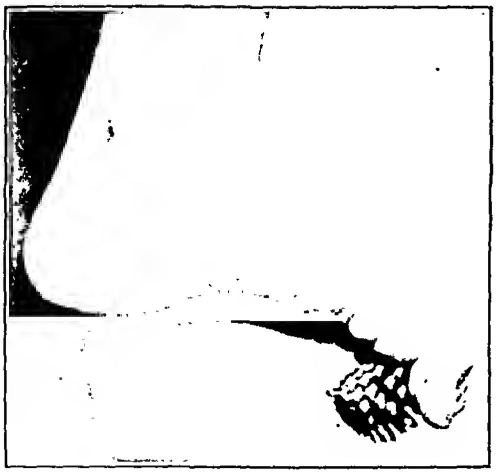


Fig. 1-B
Exercise with a pine cone.

1. Walking with bare feet on coarse and uneven ground (grass, stubbles, and pebbles).

2. Jumping rope; this improves posture and breathing, strengthens the calf muscles, and raises the arch of the foot.

3. Use of the so-called "Spitzy ball" (a wooden ball sewed on a straw sole and worn as a sandal).

4. "Towel exercises", which improve both flexion and adduction.

In order to make the treatments attractive for children, the exercises may be employed in games,—foot gymnastics with the medicine ball and the gripping and throwing of pine cones or chestnuts. (See Figures 1-A and 1-B.) Both games strengthen the musculature of the entire leg. With the help of imagination and experience, it is possible to develop innumerable combinations of exercises.

APPARATUS

The following types of apparatus, which can be made by a good carpenter and mechanic, have as their bases these corrective principles:

1. Fixation of the heel in supination;
2. Pressure of a stable correction cushion against the weakest point in the foot arch,—the talonavicular joint;
3. Regulated adduction and pointed-toe position.

All exercises must be carried out with the knee bent at right angles and the lower leg perpendicular.

The Potter's Disk

It consists of a slanting disk, forty centimeters in diameter, covered with rough rubber. (See Figure 2.) The disk revolves on four wheels and its height is adjustable by means of a screw plate. On the fixed hub there is an adjustable plate for the right and the left foot in supination. A heel clamp, which can be tightened and loosened by means of a screw, helps to fix the heel in position. Both wings of the clamp have adjustable cushions for the redressment of the talonavicular joint. The fixation is maintained by two straps. The amount of flexion can be varied by raising and lowering the disk. Movement of the disk is made difficult by means of a braking weight.

The Foot-Correction Ball

A wooden ball, about twenty centimeters in diameter, is mounted on a round joint, which makes possible its adjustment in every direction. The heel rests on a support. (See Figure 3.) By means of screw *a*, the height can be regulated; by screw *b*, the degree of supination is controlled;

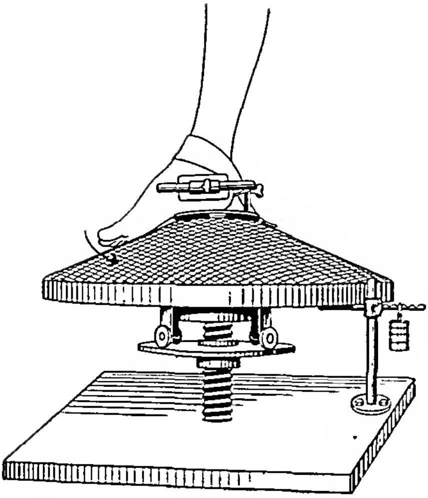


FIG. 2
The potter's disk.

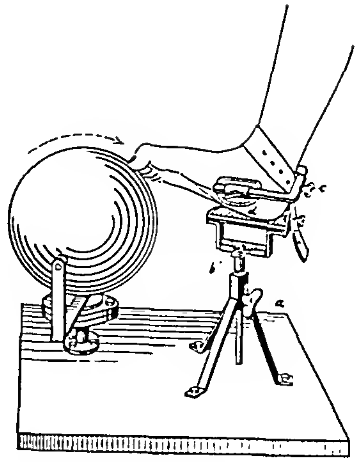


FIG. 3
Grasping exercise with the foot-correction ball.

by screw *c*, fixation of the heel is guaranteed; and by screw *d*, the correction cushion is adjusted. If the axis of the ball is horizontal and parallel to the foot, a "grasping exercise" is afforded, which can be regulated by moving the ball or by elevation of the heel support. If the axis of the ball is vertical and at a right angle with the foot, the foot is obliged to adduct in order to move the ball. The amount of adduction can be regulated in the manner just described.

Apparatus for Limbering Stiffened Flat Feet in Adults

This apparatus is shown in Figure 4. The foot rests on a fixed cushioned stirrup, *a*. A strap cuff, which is laid around the ankle and passed over the heel of the foot, is attached to the lever at *b*. Another strap is laid around the front of the foot and led over a pulley to the other end of the lever at *c*. The attachment of the straps must be made when the front of the foot is in extreme plantar flexion. The axis of the lever is connected with a bar, *d*, which permits the manipulation of the lever so that a corrective pull on the heel and front of the foot is possible. The toes rest on

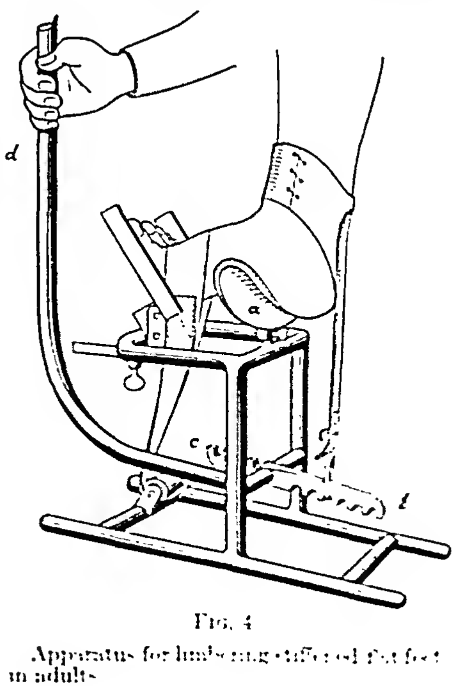


FIG. 4
Apparatus for limbering stiffened flat feet in adults

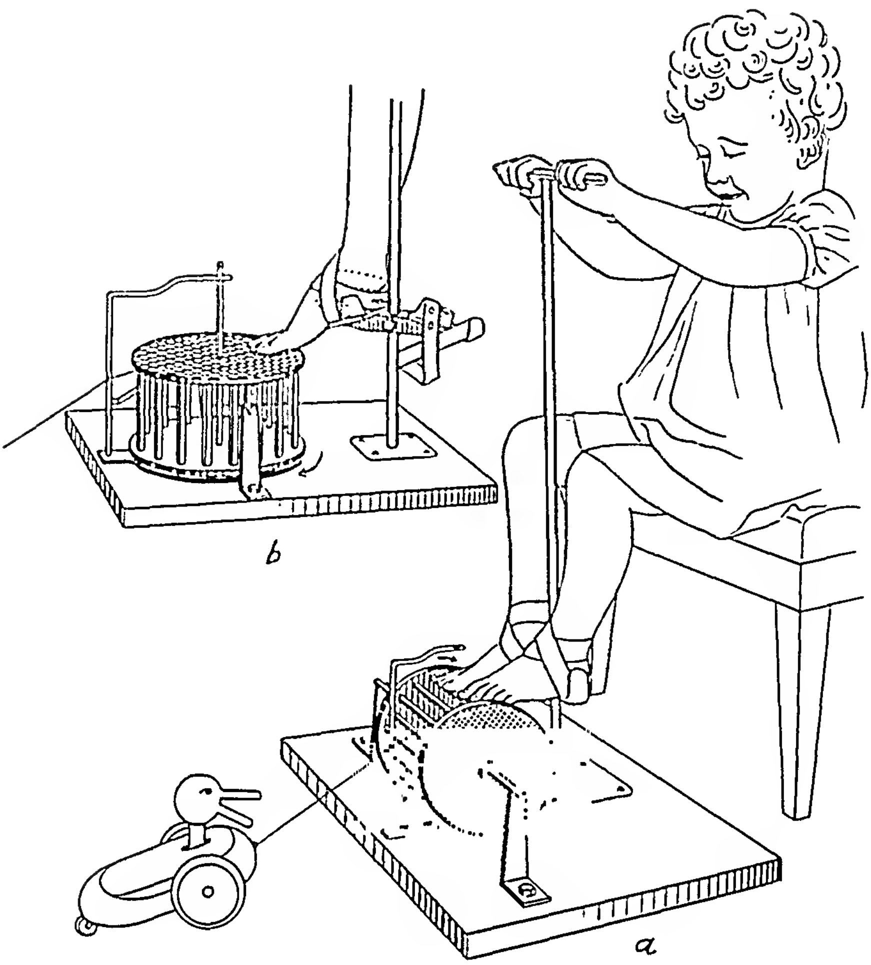


FIG. 5
The turbine wheel:
a: grasping exercises
b: adduction exercises.

an adjustable plate, which fixes and mobilizes them, so that the patient can apply the treatment himself.

The results obtained by the use of this apparatus are: (1) stretching of the Achilles tendon and pointing of the calcaneum; (2) raising of the arch in the talonavicular joint; (3) conversion of the position of the metatarsal part of the foot into pronation; and (4) shortening of the front from toe to heel together with mobilization of the toes. With the help of this apparatus, which can be used from two to three times daily for a period of from twenty to thirty minutes, the author has succeeded in preparing many stiffened and painful feet for the wearing of arches.

The Turbine Wheel

To make foot calisthenics attractive for children, the so-called "turbine wheel" has been constructed. (See Figure 5.) By means of different adjustments it permits the corrective exercise of practically all foot muscles, and it can be used for both the right and the left foot. Two parallel wooden disks, covered with rubber, about twenty centimeters in

diameter, and about thirty centimeters apart, are connected by means of wooden spokes. The resulting turbine wheel is mounted on an axle and supplied with an adjustable brake to guarantee movement in one direction only. On the same plate which carries the turbine wheel there is a metal bar to support the adjustable heel rest. The heel of the foot remains fixed in the rest by a bandage strap and a rubber correction cushion at the talonavicular joint. At the upper end of the bar there is a hand grip, so that the child can support himself. In this form (Fig. 5, *a*), the apparatus permits a flexion exercise,—the child continues to grasp the connecting spokes with the toes and propels the turbine. When the wheel is placed horizontal to the plate and the foot rest is lowered (Fig. 5, *b*), the child can practise adduction. In order to encourage the child, a small animal on wheels is attached to the turbine and, by turning the turbine, the child also moves the animal which can be weighted so as to increase the work done.

INTERNAL SPLINTING OF FRACTURES OF THE FIFTH METACARPAL

BY DAVID M. BOSWORTH, M.D., NEW YORK, N. Y.

The usual result of fracture of the head of the fifth (or other) metacarpal is unfortunate both in its roentgenographic and clinical aspects. Rarely is extension of the distal short fragment maintained. Generally union occurs in marked flexion and the prominence of the knuckle is lost. Because of the flexion, a defect persists in extension of the metacarpophalangeal joint. It is true that well-applied and well-maintained extension will generally prevent this, but it does not always do so, and it disables the patient as regards the use of the hand for three weeks and frequently longer.

Recently the pathologist at Sea View Hospital had the misfortune to suffer a fracture of the fifth metacarpal. (See Figure 1.) In this case it was necessary to devise a better, simpler, and less handicapping method of treatment than had been used in the past, and the idea of splinting the distal fragment of the fifth to the fourth metacarpal occurred to the author.

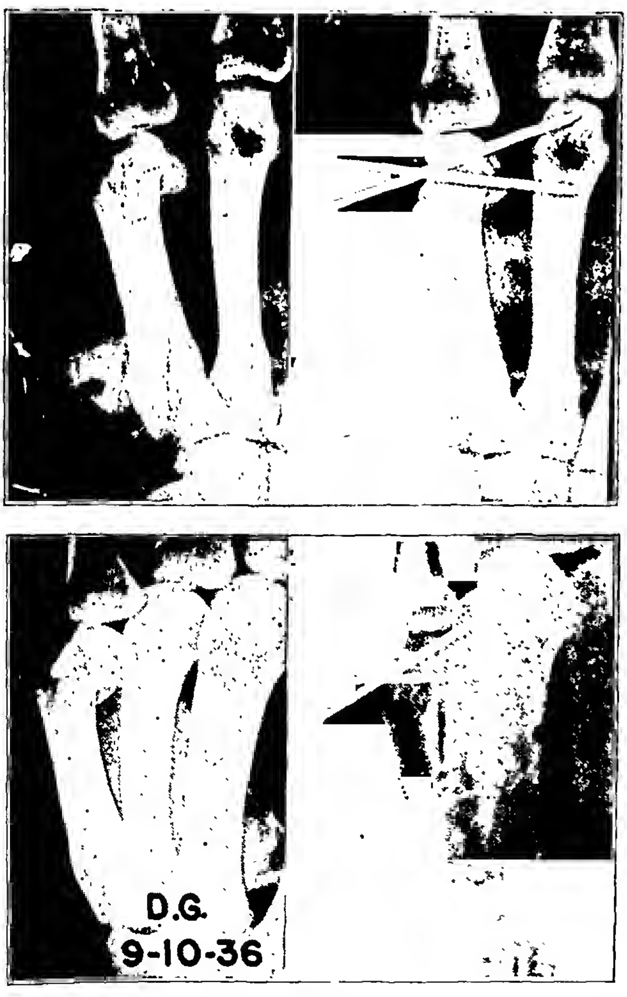


Fig. 1

Under strict asepsis and with the use of the fluoroscope, the writer manipulated the fracture into the best position obtainable (it was three weeks old), and then guided his assistant in drilling two wires at angles through the distal fragment of the fifth metacarpal into the fourth metacarpal. When these wires had been placed, the fracture was perfectly immobilized and the patient was able to move all fingers of this hand without restraint or difficulty.

The wires were clipped off a quarter of an inch outside the skin and a dressing, wrung out of Dakin's solution, was placed around and over them and strapped in place with adhesive. This

FIG. 2-A

FIG. 2-B

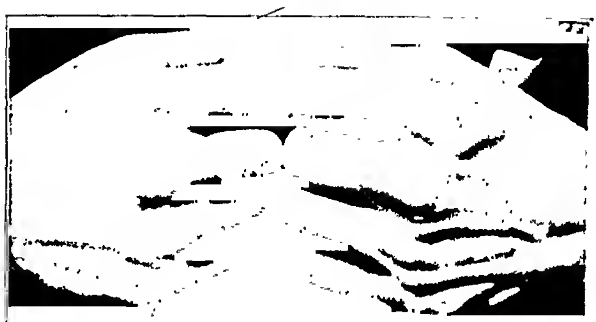


FIG. 3

small dressing was left in place for three weeks and then it and the pins were removed. Both pins were found very tightly set in the bone at that time, no absorption having taken place around them. The prominence of the knuckle was well maintained. This patient had meanwhile been able to continue with his full duties as pathologist without pain or loss of the use of any of his fingers.

In a second case (Figs. 2-A and 2-B) the pins were placed differently. One was drilled through the proximal fragment to hold it forward and the other through the distal fragment to force it backward. Stability in this case was not nearly as good and the distal fragment rotated on the wire, so that the prominence of the knuckle was not as well maintained.

Several other cases have since been treated by the first method with uniformly successful results.

UNUSUAL HALLUX-VARUS DEFORMITY AND ITS SURGICAL CORRECTION

CASE REPORT

BY M. THOMAS HORWITZ, M.D., PHILADELPHIA, PENNSYLVANIA

From the Hospital for Joint Diseases, New York, N. Y.*

J. H., a colored female, aged six, was admitted to the Hospital for Joint Diseases because of congenital deformities of both feet, that of the left disturbing her gait and inhibiting her from wearing a shoe with comfort, unless of special design.

On examination, the right foot presented syndactylism of the first and second and of the third and fourth toes, and a mild hallux varus of 10 degrees. The left foot demonstrated syndactylism of the third and fourth toes, absence of the second toe, and a severe, incorrigible first-metatarsal hallux varus of 45 degrees. (See Figure 1.)

FIG. 1

Feet before operation.

FIG. 2

Left foot six months after operation.

* Service of S. A. Jahss, M.D.

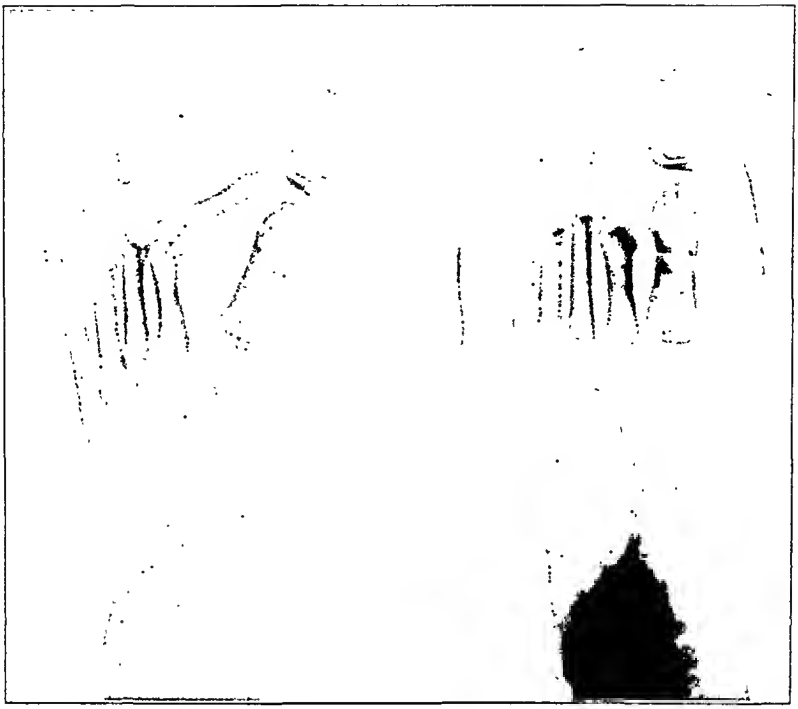


FIG. 3-A FIG. 3-B

Roentgenograms of the left foot.
Fig. 3-A: Before operation.
Fig. 3-B: After operation.

A roentgenogram of the left foot (Fig. 3-A) revealed the proximal phalanx of the second toe in a marked varus position and articulating with the epiphyseal end of the proximal phalanx of the first toe.

The following operative procedure was evolved and performed by Dr. S. A. Jahss, to correct the hallux-varus deformity of the left foot. Interference with the other congenital anomalies present was not considered indicated at this time.

A diamond-shaped portion of skin was removed from between the first and third toes, to avoid excessive redundancy, its base at the web and the apices on the dorsal and plantar surfaces, one and one-half inches from the web margin. The phalanx, articulating between the second metatarsal head and the base of the proximal phalanx of the first toe, was removed. The first and second metatarsals could now be easily approximated, but, since the varus deformity tended to recur, a strip of fascia lata was removed from the right thigh, looped through a drill hole in the first metatarsal head and about the shaft of the second metatarsal, and sutured to itself with the toe held in the corrected position. The deep tissues were closed with interrupted chromic catgut and the skin with black silk, and the correction was reenforced by a compression bandage.

The wound healed by primary union and the patient was discharged wearing ordinary shoes comfortably and without a corrective appliance. Excellent correction has been secured and has been maintained six months postoperatively (Figs. 2 and 3-B).

TREATMENT OF FRACTURES OF THE CLAVICLE

A Special Stand to Facilitate the Reduction and Application of Cast *

BY RUTH JACKSON, M.D., DALLAS, TEXAS

Chief of Orthopaedic Staff, Parkland Hospital, Dallas

Fractures of the clavicle can usually be reduced by the ordinary methods, but the maintenance of the reduction until some form of apparatus for immobilization can be applied has been our greatest problem. The stand shown in Figure 1-A was designed to facilitate reduction of these fractures and the application of a shoulder spica. It is thirty-seven inches high and has a "shoulder seat" and head rest which are adjustable, so that the stand can be used with a table of almost any height. The shoulder seat is a solid strip of metal, thirteen inches long and one and three-fourths inches wide, with the edges slightly beveled to prevent injuring the skin. Three and one-half inches of the shoulder seat project beyond the center of the stand toward the head rest, and the head rest is seven inches from the center of the stand.

As shown in Figure 1-B, the patient's pelvis and lower extremities remain on the table and the stand is placed beneath the upper part of the

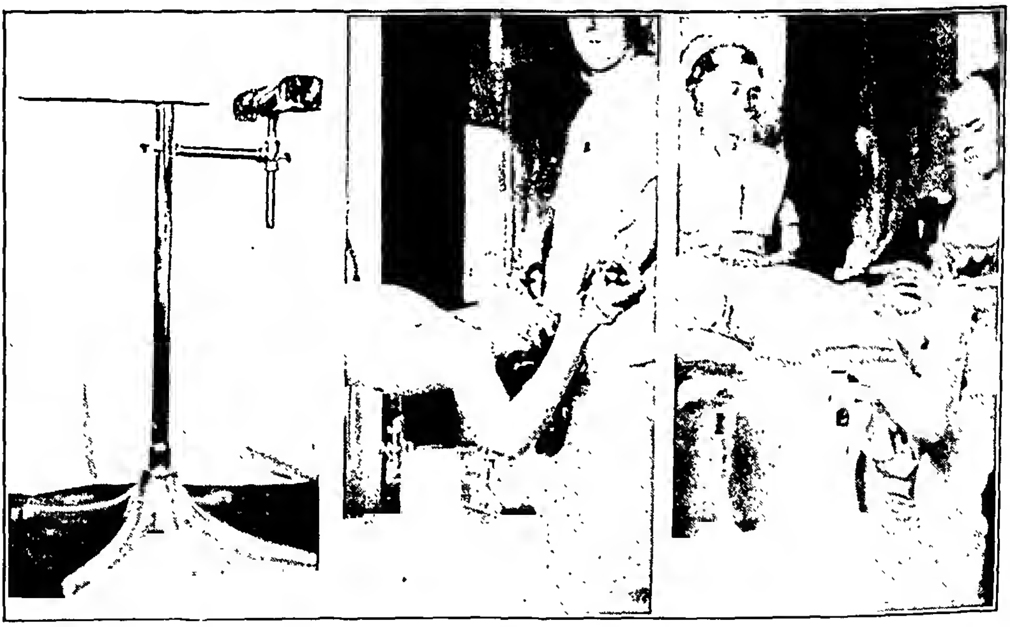


Fig. 1-A　　Fig. 1-B　　Fig. 1-C

Fig. 1-A: Clavicle stand. The shoulder seat and head rest are adjustable.
Fig. 1-B: Patient ready for reduction.
Fig. 1-C: After reduction and application of cast.

* Presented at the Meeting of the Clinical Orthopedic Society, Dallas, Texas, November 6, 1936.

body, so that the shoulder seat is between the shoulders and the head lies upon the head rest. An assistant holds the arms until a local or general anaesthetic is given. Then the arms are abducted to 80 or 90 degrees and allowed to drop backward as far posterior to the posterior plane of the body as possible, the elbows are flexed, and the assistant maintains this position by holding gently the tips of the patient's fingers. The upper part of the body is easily balanced on the stand by keeping both arms in this position. The weight of the arms pulls the shoulders backward, upward, and outward, and thus maintains constant traction in the long axis of the clavicle.

The surgeon can then very easily manipulate the fragments into position and apply a plaster-of-Paris shoulder spica without in any way altering the position of the fragments. (See Figure 1-C.) When the plaster has set, the stand can be removed by slipping it backward, thus removing the shoulder seat from beneath the cast. The patient is then placed on the table. When the cast is dry, the patient is allowed to be ambulatory. The cast is worn for three or four weeks.

In forty cases of fracture of the outer three-fourths of the clavicle, treated at Parkland Hospital, we have had 100 per cent. excellent reductions, while previously the residents and internes were reducing only about 25 per cent. of such fractures. We feel, therefore, that this stand is very practical in the treatment of fractures of the clavicle. We have also found it useful in treating acromioclavicular dislocations, and for applying any shoulder spica.

A PNEUMATIC TOURNIQUET

BY W. C. CAMPBELL, M.D., MEMPHIS, TENNESSEE, AND H. B. BOYD, M.D., LOS ANGELES, CALIFORNIA

Much damage is often observed after the application of the tourniquets in common use for securing hemostasis in surgery of the extremities. This is apparent from the frequent occurrence of persistent neuritis and tourniquet paralysis which may last for a considerable length of time and, occasionally, may result in permanent damage of nerves and blood vessels. This is most common in the upper extremity.

Therefore, over a period of ten years, one of the authors has experimented with various types of pneumatic tourniquets in an effort to devise an apparatus by means of which pressure could be evenly applied over a large area and the exact amount of pressure could be determined. We have at last secured an instrument which meets these requirements and which will soon be on the market.

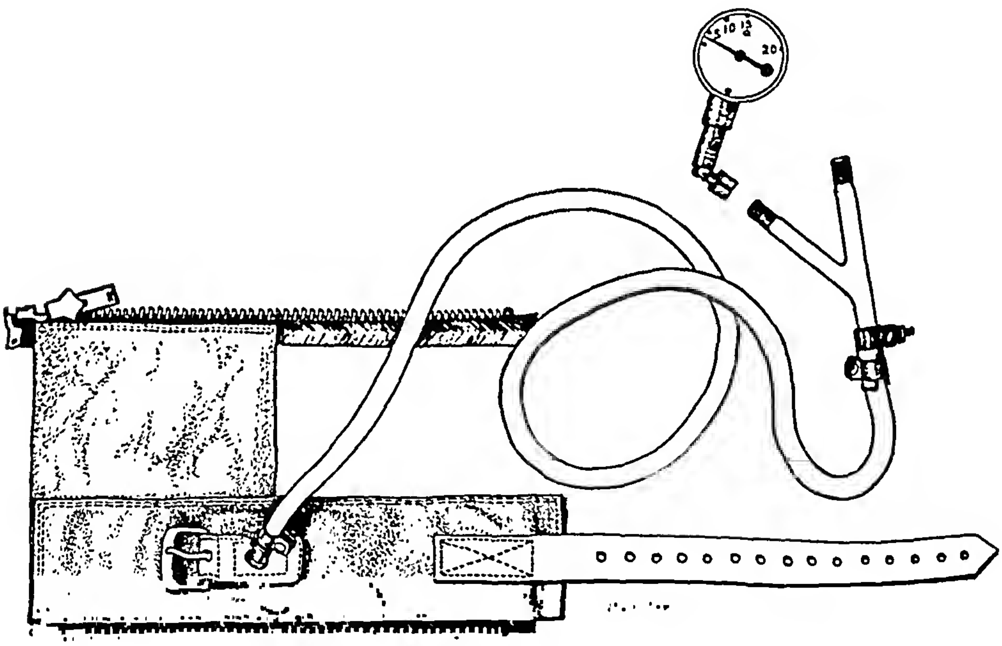


FIG. 1

In constructing this apparatus, an inner tube from a bicycle balloon tire (two and one-fourth inches in diameter) is used. A section, of the proper length to go around the extremity and to overlap two or three inches, is cut. The ends are vulcanized and an ordinary automobile valve stem is inserted in the middle on the convex surface. The valve core is removed from this valve stem. One end of a section of pressure tubing, three feet long, is then slipped over the end of the valve stem and the connection is made air-tight. To the other end of the pressure tubing a Y-shaped valve stem is attached. Valve stems are placed in each open-

ing at the top of the Y. To one of the legs of the Y a pump is attached to inflate the tourniquet. The other outlet is used for testing the pressure. Thus the tourniquet may be inflated as an inner tube, and the pressure may be tested without removing the pump. A bicycle or automobile pump may be used to inflate the tourniquet.

The inner tube described is incased in a complete soft-leather casing. A buckle is attached near the valve stem and a strap is fastened to the opposite end of the casing. We found that, when the tourniquet was inflated, the ends slipped out from beneath the overlapping portion of the casing, allowing the inner tube to expand and to release the pressure. A second flap was then added to the casing to cover the overlapping portion and the strap. This was sewed to one side of the casing and fastened to the other side by means of a zipper which is detachable at both ends.

The amount of pressure required depends upon the size of the individual extremity. For an average-sized adult, fifteen pounds of pressure for the thigh and ten pounds of pressure for the upper extremity are the maximum. The pressure for children is proportionately lower.

A pneumatic tourniquet should not be used unless the exact amount of pressure can be measured. For testing the pressure, we have employed a football gage to which an adapter for testing automobile inner tubes has been attached. This gage is used because the ordinary automobile gages do not register accurately between five and fifteen pounds of pressure, which is the range needed.

The one disadvantage of this pneumatic tourniquet is the expense of having three different lengths of tourniquets to fit various sizes of extremities. This is important, as the tourniquet must fit properly and the tube should overlap two inches or more in order to function satisfactorily.

This pneumatic tourniquet has the following advantages:

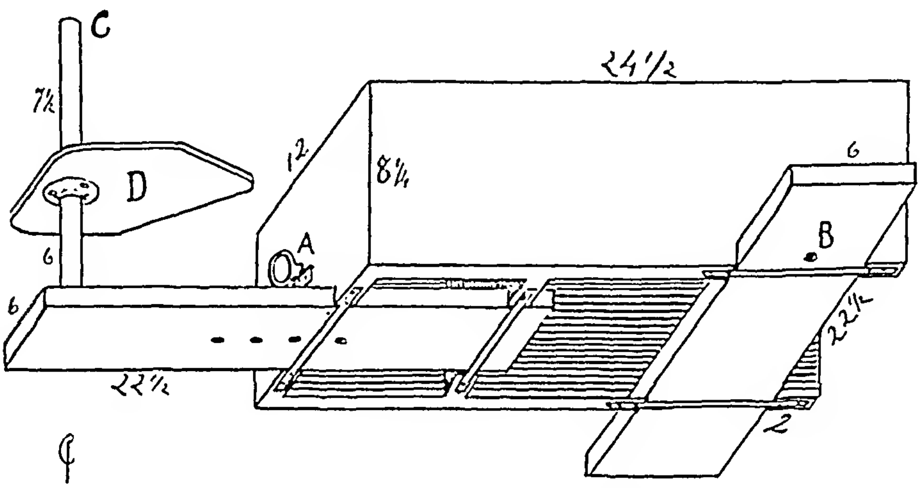
1. Pressure is applied evenly over a large area, and the exact amount of pressure is known. This may be the means of preventing tourniquet paralysis.

2. It is easily applied and may be deflated at any time without disturbing the operator or the sterile surgical drapes. This often saves valuable time during the course of an operation.

A "SPICA BOARD" OR BOX

BY F. J. COTTON, M.D., BOSTON, MASSACHUSETTS

Many times in the past the author has felt the need of a really transportable apparatus for use in applying plaster spicas in cases where no Hawley table was available. Therefore, some ten years ago, he devised the spica board shown in the accompanying drawing. It has seen much service and has proved so useful that the author feels it may be of value to others.



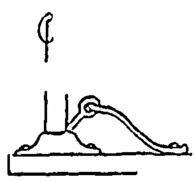


FIG. 1
Working drawing of spica board seen from below and from the side. The dimensions indicated are in inches.

This spica board is a box, without bottom or back, and is made of wood, three-quarters of an inch thick, with slots cut in the end in which the two boards slide. These boards are held in place in the slots by thin metal strips. The longitudinal board is prevented from slipping by a small spring catch, or barrel lock, at *A*, on the front face; the board is held at the desired length by dropping the key down through the appropriate hole. A similar catch on one side drops into the hole, *B*, and holds the cross-board which prevents sidewise tipping. The upright, *C*, is of brass tubing, one inch in diameter. The lower section is screwed into a threaded socket and is kept from rotating by a removable pin, set in through thread and socket. This pin is secured against mislaying by a small leather strap as shown in the inset, *E*. This lower portion, a six-inch post, carries the sacral support, *D*. The upper part, seven and one-half inches long, is removable, screws into a socket just like that on the lower side of *D*, and acts as a perineal support.

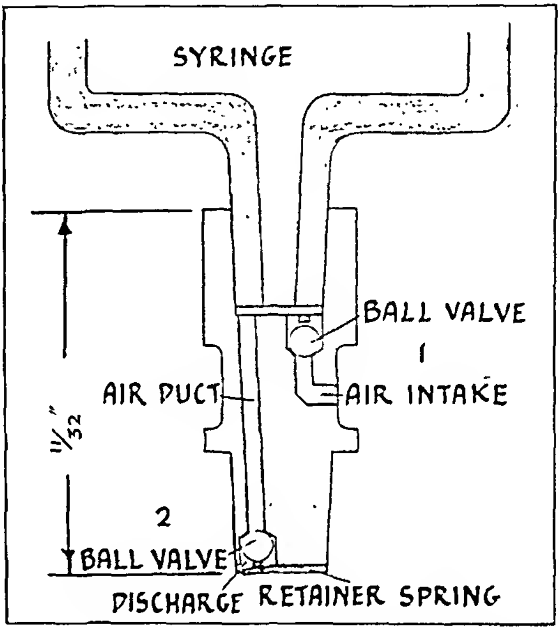
This board was designed so that all the parts, when disjointed, will fit into the main box, and the proportions are such that the apparatus can be carried in an automobile and also placed under a pullman berth. Its construction is simple and can be duplicated by any good mechanic.

A NEW AUTOMATIC VALVE FOR MEASURING AIR INSUFFLATIONS

BY CHARLES MURRAY GRATZ, M.D., NEW YORK, N. Y.

From the Department of Surgery, Division of Orthopaedics, and the Department of Mechanical Engineering, Columbia University, New York

Air has been used for many years for diagnostic and therapeutic purposes in the treatment of pathology involving the lungs and the central nervous system. It also has a small but definite rôle in aiding the surgeon in localizing pathology in the various joints of the human body and the fascial planes. If oxygen is used, it is quite easily measured as it leaves the container, but, if atmospheric air is employed, the armamentarium for injecting and measuring it is rather scanty. If the ordinary syringe is used, its capacity is rarely sufficient for the injection of the desired amount of air without disconnecting the needle. A variable amount of air is inevitably lost when the syringe is removed for refilling. This may interfere with the accuracy of placing the needle and, in addition, the amount of air lost diminishes the accuracy of the procedure.



An automatic valve has been devised which fits a standard Luer syringe and also the standard size of needles. The accompanying illustration shows the details of construction. On the up stroke of the syringe, valve *1* opens and valve *2* closes. Air enters the syringe through the intake and the syringe is filled and the air measured. On the down stroke of the syringe, valve *1* closes and valve *2* opens. This permits the air to be injected through the needle. These valves convert the syringe into a self-measuring pump.

It was very difficult to design an automatic valve of such small dimensions as the one herewith presented. All of the mechanical features were designed by G. B. Karelitz, Professor of Mechanical Engineering, Columbia University, and by Mr. V. I. Zelov. These minute valves of stainless steel should be cleaned with benzine before sterilization and tested each time before being used clinically. They have been found to simplify as well as add to the accuracy of surgical procedures where insufflation is indicated.

A BRACE FOR ARTHRITIC HIP JOINTS

BY DON KING, M.D., F.A.C.S., SAN FRANCISCO, CALIFORNIA

Department of Surgery, Division of Orthopaedics, Stanford University Medical School

One is often surprised at the range of flexion retained by a hip joint, the seat of an advanced degenerative arthritis (malum coxae senilis). Usually there is a fixed external rotation present and any attempt to rotate the thigh causes pain. Close questioning of the patient frequently elicits the information that the hip is more painful when walking on an uneven surface,—*i.e.*, when there is a tendency for rotation to occur.

Hohmann has suggested that a brace, which permits flexion but prevents rotation, will often relieve the pain from which such old people suffer.

During the past two years the writer has used this brace on twelve patients and has found it so satisfactory that he feels justified in reporting it here. Three of these patients have been relieved of pain completely; five others report marked improvement; one feels that there has been slight improvement; and the remaining three have had no improvement whatever.

BRACE CONSTRUCTION

The pelvic belt is a half oval of 18-gage flexible steel, one inch wide. A short upright with a hinge or joint attached is riveted to the belt. Attached to the flexion joint is an upright bar of tempered steel, one-half by five-eighths of an inch, which is curved anteriorly across the thigh, about four inches above the patella. The vertical upright bar is fastened

Fig. 1

Side view. Brace applied.

Fig. 2

Front view.

to the thigh by means of two 22-gage duraluminum pelotes, three to three and one-half inches long and seven to eight inches wide. The upper pelote grips the thigh laterally and is fastened to the bar by a swivel rivet. The fixation is done by a single strap of webbing, one and one-half inches wide, encircling the thigh and fastening to a buckle anteriorly.

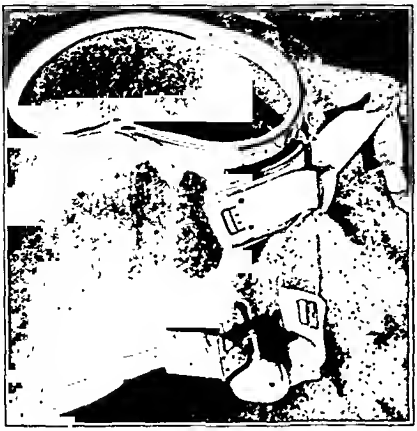


Fig. 3
Front view.

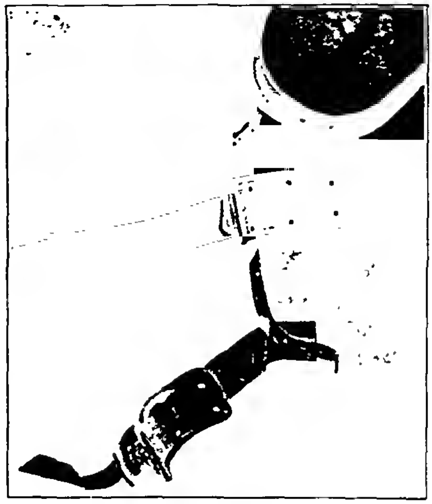


Fig. 4
Inner aspect of brace.

The lower pelote closes the circle begun by the curved portion of the upright bar about four inches above the patella, and extends around the posterior aspect to the outside of the thigh, where it is fastened to the upright bar by another webbing strap.

The apparatus is finished by felt pads, one-quarter of an inch thick, sewed onto a firm leather backing and riveted to the belt and the pelotes.

A shoulder strap (not shown in the illustrations) over the opposite shoulder helps to carry the belt in position and keeps the brace from slipping.

REFERENCE

Hohmann: Eine neue Bandage für die chronisch-deformierende Gelenkentzündung des Hüftgelenks. Münchener Med. Wchnschr., LXXIX, 49, 1932.

A BRACE FOR THE CORRECTION OF SPASTIC PRONATION CONTRACTURE OF THE FOREARM

BY MICHAEL S. BURMAN, M.D., NEW YORK, N. Y.

From the Hospital for Joint Diseases, New York, N. Y.*

The purpose of this brace is the gradual passive correction of pronation contracture of the forearm in spastic paralysis.

It consists of an upper-arm piece which is fitted to the anterior aspect of the arm. The upper-arm piece articulates with the upper-forearm piece at a point which is placed on a level with the epicondyles of the elbow joint. Flexion and extension are allowed at the elbow joint, but are controlled by a set screw. An elevated shoulder, acting as a guide in rotation for the forearm piece, is riveted to the upper-forearm piece on its anterior aspect and is placed at the level of the head of the radius when the brace is applied. The forearm piece fits smoothly against the shoulder of the upper-forearm piece, rotates along it, and is maintained in position by a slotted strip of metal which is screwed to the shoulder. A set screw, which moves in the slot, fixes the amount of rotation. The hand piece is riveted to the forearm piece. The thumb is maintained in abduction by a thumb-piece attachment which is well padded, since it is a point of pressure. The hand piece holds the wrist dorsiflexed. It is open dorsally for easier application of the apparatus. The

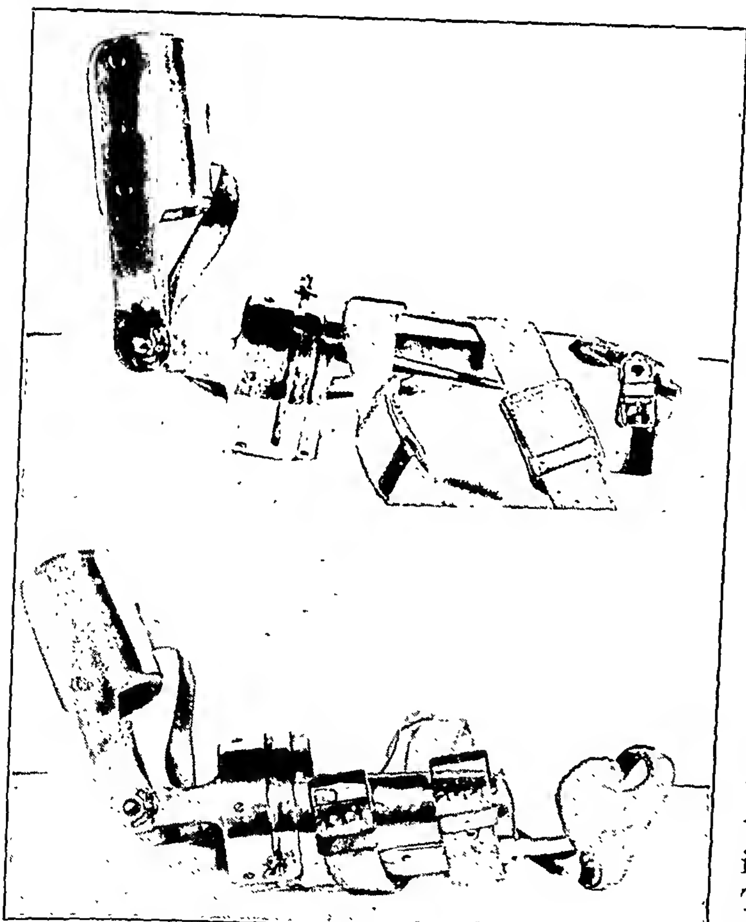


Fig. 1

The lower picture shows the position of the apparatus in pronation. The forearm piece is rotated and fixed in supination in the upper photograph.

*Service of Leo Mayer, M.D.

hand is kept in position by a dorsal strap.

The brace passes above the upper radio-ulnar joint and below the lower radio-ulnar joint, so that it controls the two joints entering into pronation and supination. It includes the hand and exerts thereby a stronger leverage effect. This leverage effect is increased if the elbow is maintained at 90 degrees of flexion by the set screw. The thumb piece keeps the thumb out of the palm. A pressure sore can develop over the thenar eminence if too great a pressure is used at first.

It is not necessary that full supination be reached. All that is needed is accomplished by midposition or a position in supination just a little beyond it.

The author wishes to acknowledge the assistance in making this brace of the late Mr. Otto Feineis and Mr. Alvin Laubender, formerly connected with the Brace Department of the Hospital for Joint Diseases.

FIG. 2

The brace has been disassembled and its component parts are shown.

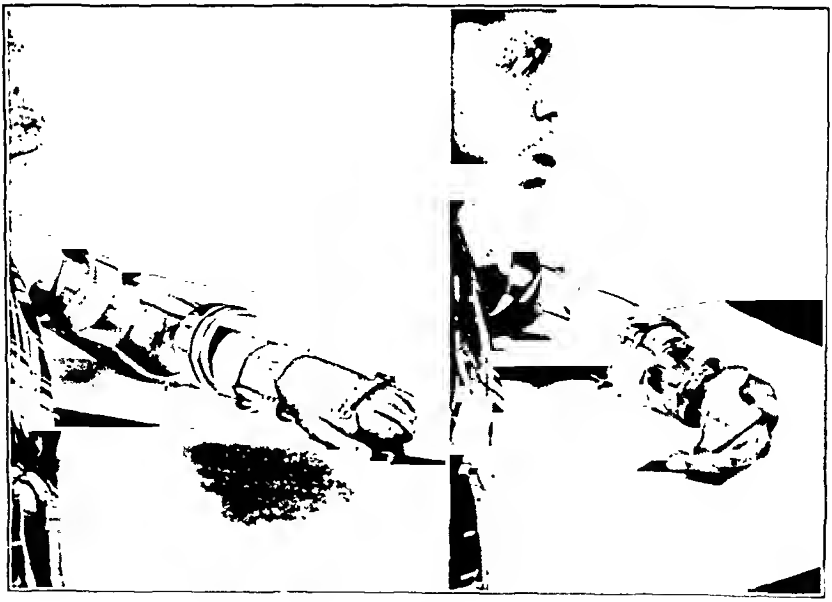


FIG. 3

This shows the brace applied to the arm. In the view on the left, the brace is in the position of pronation: in that on the right, the forearm has been supinated.

A PORTABLE FRAME FOR THE APPLICATION OF HIP AND SHOULDER SPICAS AND CALOT JACKETS

BY ROBERT MAZET, JR., M.D., MANHASSET, LONG ISLAND, NEW YORK

The frame shown in Figures 1 and 2 is an adaptation of the De Croquet frame and Dr. E. H. Oppenheimer's shoulder rest.

It consists primarily of the De Croquet frame. The shoulder rest is made of two rectangular sheets of 13-gage steel, fifteen by eight inches, set eight inches apart on a steel rod, seven-sixteenths of an inch in diameter. The sacral rest consists of a similar sheet of steel as a base on which a pipe,

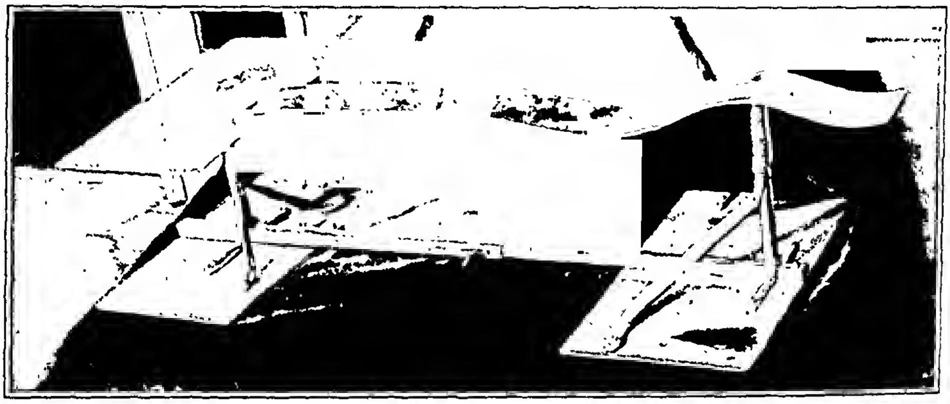


Fig. 1

Fig. 2

one-half an inch in diameter, supports the seat eight inches from the table. The sacral rest and perineal bar are detachable. The bases of the two rests are connected by a sliding rod to permit adjustments for length of the torso.

For the application of a shoulder spica the position of the patient on the frame is reversed,—the pelvis is supported by what was the shoulder rest, and the shoulders by the back rest which fits onto the upright that formerly supported the sacral seat.

The back rest (Fig. 3) consists of a piece of 13-gage steel, twenty-nine and one-half by three inches, curved to fit the cervical spine and occiput. This conformation to the anatomy is a considerable aid in keeping the patient from slipping off sideways. Beneath the neck curve, six inches

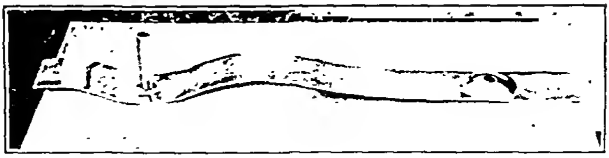


Fig. 3

from the end of the rest, a pieee of pipe, seven-sixteenths of an ineh in diameter, fits over the rod that supported the sacral seat of the De Croquet frame. Five inches from the other end of the back support is a beveled doughnut, five-eighths of an inch high with a hole, one-half an inch in diameter, in its center. When the baek rest is in position, its lower end rests on the pelvie support and its upper end on the other basc. This support is withdrawn from above after application of the plastcr. It may be used with a Hawley table.

Thc frame is nickel plated, and weighs twenty pounds; it should havc been made of a lighter alloy.

To use the frame for applying a Calot jaekct, the back support is reversed and the doughnut is placed on the cephalad upright. The head and neek hang over the end of the back rest and must bc supported by a Barton bandage or a Sayre sling. After the plaster dries, thc back support is withdrawn from below.

This frame may also be used to apply figure-of-eight bandages for fraeture of the claviele.

INTERNAL-ROTATION BRACE FOR FEMUR

BY HENRY MILCH, M.D., F.A.C.S., NEW YORK, N. Y.

Associate Attending Orthopaedist, Hospital for Joint Diseases, New York City*

In a recent article on the treatment of epiphyseal coxa anteverta [1], it was suggested that the simple Thomas walking hip brace is unsatisfactory, since it cannot prevent external rotation of the leg, which is the essential requirement in treating the disease. In an effort to surmount this difficulty, a pelvic band with a simple hip joint was added to the brace. This seemed to improve the appliance, but did not constantly and completely maintain the desired position of internal rotation. To avoid the necessity for constant re-adjustment, it seemed desirable to append a short leg piece to the opposite leg, to act as the fixed point against which internal rotation of the affected leg could be accomplished through the pelvic band.

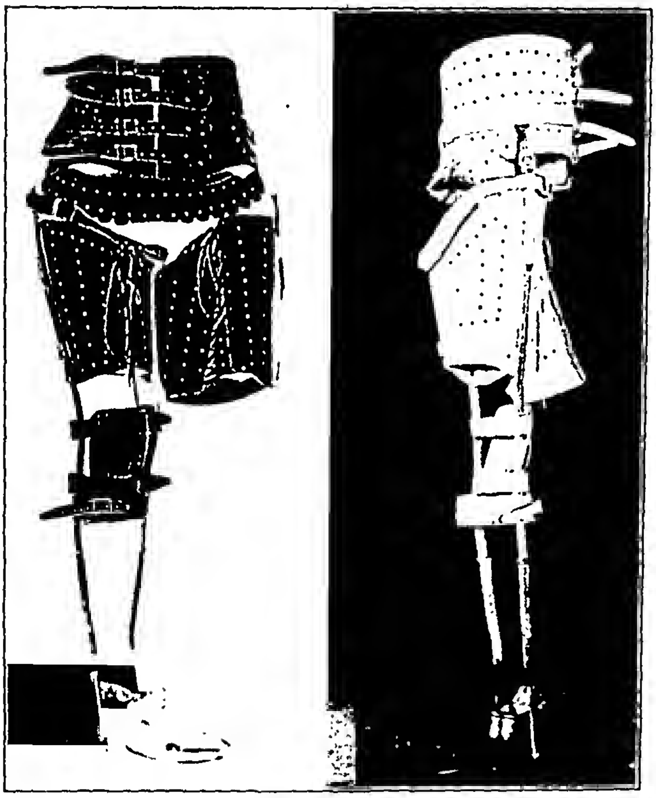


FIG. 1

Front and lateral views of brace without knee joint on affected side, and with simple hinge joint on well side.

Such a brace is shown in Figure 1. It consists of a walking caliper portion for application to the well leg. Where expense is of no moment, a knee joint may be supplied. The leg part is fixed to the pelvic band by means of a simple joint, which permits only flexion and extension. Internal rotation is accomplished by twisting the portion about the hip joint. To the well leg a short thigh piece is added and this is fitted with a simple or a universal joint. This brace is at present being used with complete satisfaction.

1. MILCH, HENRY: Epiphysiolysis or Epiphyseal Coxa Anteverta. J. Bone and Joint Surg., XIX, 97, Jan. 1937.

* Service of Harry Finkelstein, M.D.

ACUTE NEISSERIAN INTRAPELVIC PROTRUSION OF THE ACETABULUM (OTTO PELVIS)

BY DAVID SLOANE, M.D., AND MARIAN FRAUENTHAL SLOANE, M.D.,
NEW YORK, N. Y.

From the Orthopaedic Division of the New York City Hospital *

We wish to present a series of observations on a case of acute intrapelvic protrusion of the acetabulum of Neisserian origin. The period of study covered an entire year and the pathological process was roentgenographically and clinically observed from onset to termination.

CASE REPORT

A. D., white female, aged eighteen, employed as a domestic, was admitted to the New York City Hospital in October 1935 with a low-grade fever and a swollen right knee and hip. The pain was severe and unrelieved by salicylates. There was a history of vaginal discharge for the past two months with bilateral abdominal tenderness and adnexal pelvic masses.

While in the Hospital the patient's temperature varied from 103 to 106 degrees over a three-month period, and she was acutely ill. The urine contained albumin and casts. The sedimentation time was twenty-five minutes.

The blood count was as follows:

Red blood cells	3,200,000
Hemoglobin	50 per cent.
White blood cells	8,500
Polymorphonuclear neutrophiles	78 per cent.
Transitional cells	7 per cent.
Lymphocytes	15 per cent.

The Wassermann and Kahn tests were both negative. Cervical and urethral smears were positive for gonococci, and the complement-fixation test was positive on three different occasions. Roentgenograms of the chest were negative.

The patient was seen in consultation as an orthopaedic problem and placed in traction. During this period the acute intrapelvic protrusion developed, in spite of the traction and non-weight-bearing.

Our roentgenologist, Dr. George J. Plehn, reported on November 12, 1935, that examination of the right hip (Fig. 1) revealed a diminution of density, suggesting marked atrophy of the head and part of the femoral neck, although the contour of the acetabular rim was intact. Nine days later, in spite of continuous hip traction, roentgenographic examination (Fig. 2) showed that there was a pathological process involving the right hip, in which the femoral head showed some destruction. There were productive changes about the floor of the acetabulum, extending into the pelvic cavity in the region of the ischial spine. The head of the right femur seemed to be deeper in the acetabular cavity than normally. This marked the beginning of the formation of an Otto pelvis. The femoral head, in spite of its partial destruction, was pushing the acetabular floor medially into the pelvis.

Traction apparently was incapable of controlling the acuteness of the process or even of making the patient comfortable. Accordingly, on December 2, 1935, she was placed in a plaster spica which included the right hip and extended to the toes. The hip was placed in a position of flexion and abduction. The spica was kept on for four months.

* Service of Lyman W. Crossman, M.D.

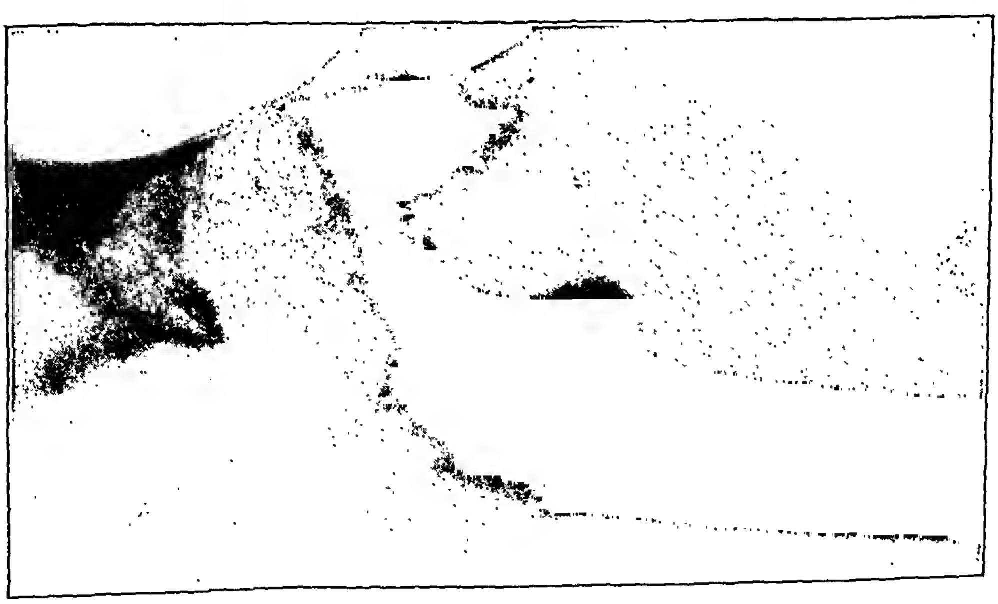


FIG. 1

Roentgenogram, taken on November 12, 1935, showing the acute process at its height. Note the marked atrophy of the head and neck of the femur. The joint margins are indistinct, due to effusion into the hip joint.

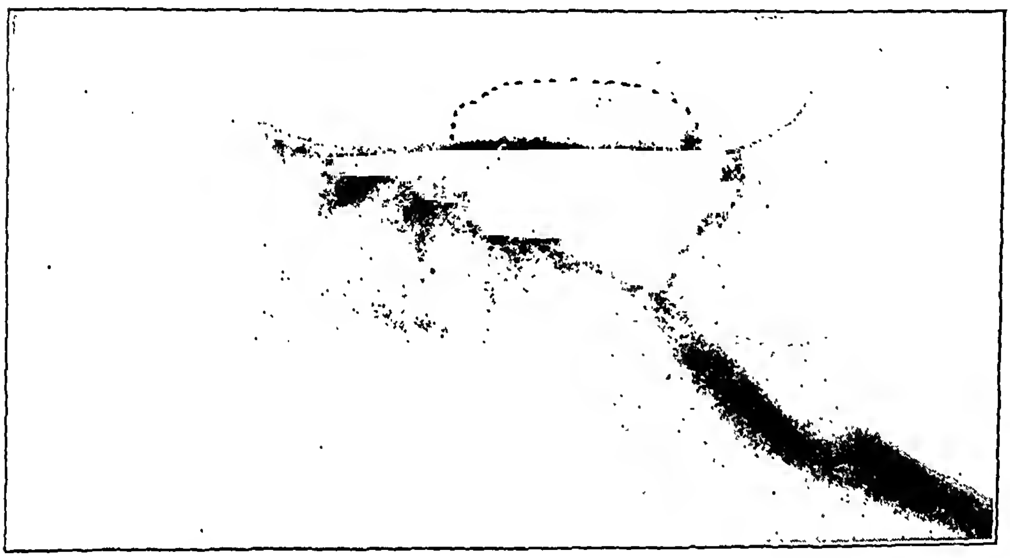


FIG. 2

November 21, 1935, nine days later than Fig. 1. Development of an Otto pelvis has begun. The pelvic floor protrudes medially as shown by the dotted line. The greater *trochanter* is still *far* removed from the ilium.

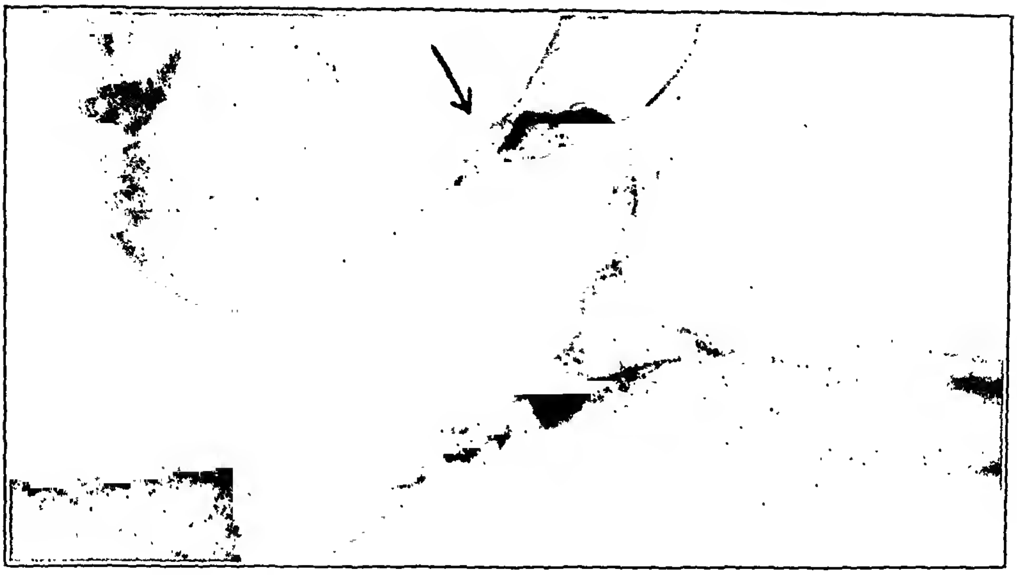


FIG. 3

October 1936, eleven months later than Fig. 1. The arrow marks the definite bulging Otto pelvis. The *greater trochanter impinges upon* the ilium.

During this period, roentgenograms showed increasing protrusion of the head and, finally, signs of joint fusion.

The cast was removed and diathermy begun on April 10, 1936. On May 22, 1936, the roentgenographic report was as follows: "The head of the right femur has been jammed into the acetabular cavity, so that only a thin rim of bone separates the head from the pelvic cavity. The head is partially destroyed and appears to be ankylosed as a result of the destruction about the right acetabulum."

Examination of the patient, prior to discharge from the Hospital in June 1936, revealed the following: "Patient walks with crutches. As she stands, her right hip and knee are in flexion and her foot is in equinus. This is due to the fact that her right hip is firmly ankylosed in 45 degrees of flexion, 30 degrees of abduction, and 45 degrees of external rotation. The knee flexion and the equinus of the foot are purely compensatory, so that she may touch the ground on walking. Motion of the right knee shows flexion to an angle of 95 degrees and extension to 165 degrees. All pain, swelling, and fever have disappeared."

The patient was readmitted for further study in October 1936. The status of the hip was unchanged. The slight limitation of motion in the right knee had completely disappeared. She walked surprisingly well and could attend to her daily duties. The only thing that bothered her was the cosmetic effect of the externally rotated position of the right foot. We did not believe a corrective osteotomy was indicated at this stage, so she was referred to our Clinic for further observation. Roentgenograms (Fig. 3), taken at this time, showed a definite Otto pelvis. The floor of the acetabulum bulged medially. The head of the femur showed slight destruction and was fused to the acetabulum in which it was deeply embedded. The greater trochanter almost touched the ilium. The lesser trochanter was very prominent, indicating marked external rotation. There was apparent foreshortening of the femoral neck because of this external rotation.

DISCUSSION

Intrapelvic protrusion of the acetabulum is today regarded as a disease process rather than a distinct clinical entity. Any pathological process which weakens the floor of the acetabulum and allows the head of the femur to progress inwardly is capable of producing this deformity. Two main groups are recognized: (1) the acute, rapidly destructive, infectious type; and (2) the slowly progressive, chronic type which occurs during the course of any disease that weakens the acetabular floor. Our case definitely comes under the acute infectious group. Many of these acute infectious hip joints go on to complete ankylosis. Why an Otto pelvis developed in our case before ankylosis occurred is somewhat of a question. It is quite probable that the acuteness of the process so rapidly weakened the acetabular floor that the head of the femur progressed inwardly before ankylosis took place. A comparison of Figures 1 and 2, which were taken only nine days apart, illustrates the great rapidity of the process.

We have been able to locate and tabulate 106 cases in the literature to date. Of this number, only thirteen were assumed, or proved, to be of Neisserian origin. This accounts for only 12 per cent. of the reported cases. We may safely ascribe our case to Neisserian origin, because the patient had a profuse leukorrhoea and adnexal masses, the complement-fixation test was positive, and the cervical smears were positive at the very onset of the joint symptoms.

SUMMARY

A series of observations, covering a period of an entire year, were made in a case of acute Otto pelvis in a girl of eighteen. Roentgenograms demonstrated the onset and rapid development of the acetabular protrusion. Pathological data pointed to a Neisserian origin. The process subsided when ankylosis ensued.

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WAY-SUNG NEW

1892–1937

With regret, *The Journal* announces the death, on May 4, 1937, of Dr. Way-Sung New, of Shanghai, China, where he had established himself in a prominent and important position in the short time during which his health permitted him to carry on the task which he had set for himself. For several years Dr. New was Foreign Editor of *The Journal* in China and was a most valuable means of contact with that country.

Dr. New was born on June 14, 1892. He was a graduate of St. John's University, Shanghai, and of Harvard Medical School. In addition to his connection with other hospitals, he served an interneship on the Orthopaedic Service of the Massachusetts General Hospital.

He returned to China with the purpose of establishing orthopaedic surgery in Shanghai. It was always his ambition to take to his country the teachings and the methods which he had followed in the United States. He established an orthopaedic hospital, supported and conducted by the people of China (the first of its kind in his country), which has been in active operation for about twenty years and has done pioneer work in the care of crippled children, as well as in the treatment of bone and joint diseases. In addition, Dr. New took a very active part in the development of his specialty in China, in affairs of general medical and surgical interest, and in giving opportunity to the surgeons in his country. He served as President of the China Medical Society, and held the position of Professor of Orthopaedic Surgery in the St. John's University Medical School and in the Women's Medical College in Shanghai. His loss will be keenly felt by the profession and by his community.

JOSEPH ISOLIN MITCHELL

1895–1937

On April 7, 1937, Joseph I. Mitchell died after a brief illness, at the age of forty-one. Dr. Mitchell received his premedical and medical education in Memphis, obtaining the degree of Doctor of Medicine from the University of Tennessee Medical School in 1919. He served a Fellowship in Orthopaedic Surgery at The Mayo Clinic from 1919 to 1923, subsequently receiving the degree of Master of Science from the University of Minnesota in 1924. Thereafter, until his untimely death, Dr. Mitchell was associated with the Willis C. Campbell Clinic, of Memphis, Tennessee. He was an Associate Professor of Orthopaedic Surgery at the University of Tennessee. On the attending staff of several Memphis hospitals, and head of the Orthopaedic Service of the John Gaston Hospital, Dr. Mitchell worked well and industriously.

As an active member of many medical societies, including the American Orthopaedic Association, the American Academy of Orthopaedic Surgeons, and the Clinical Orthopedic Society, Dr. Mitchell's contributions to his specialty were numerous and valuable. He published articles on many subjects, including anterior poliomyelitis, scoliosis, knee-joint surgery, acute osteomyelitis, correction of old traumatic deformities, and surgical treatment of affections of the lumbosacral and sacro-iliac joints.

To those who were fortunate in knowing him well, his death means the loss of a modest, sincere friend whose knowledge and judgment were greatly valued. Although rather reticent about expressing opinions, he was an unusually clear thinker and wise counsellor when consulted. In his death Orthopaedic Surgery has suffered a distinct loss.

News Notes

The Fifty-First Annual Meeting of the **American Orthopaedic Association**, which commemorated fifty full years of the existence of the Association, was held in Lincoln and Omaha, Nebraska, on June 2, 3, and 4, 1937, under the presidency of Dr. H. Winnett Orr. Special preparations were made by the President to make this Golden Anniversary of particular interest to the members and guests. Four foreign guests were present: Mr. R. Watson Jones, Liverpool; Dr. Svante Orell, Stockholm; Dr. Alberto Inclán, Havana; and Dr. Lelio Zeno, Rosario.

A particularly interesting program was arranged by the Program Committee. The list of papers which were presented will be found on page 543 of the April issue of *The Journal*. In addition, papers were presented by Dr. Zeno and Dr. Inclán.

At noon on June 3, the members were received by Governor Roy L. Cochran at the Capitol, where they were given an opportunity to inspect this unusual building.

The Annual Banquet was held on June 3 at the Cornhusker Hotel in Lincoln. At this dinner Dr. Orr gave his President's Address on "The Contribution of Orthopaedic Surgery to the Lister Antiseptic Method" and Dr. Robert B. Osgood gave a very comprehensive review of "The History of Orthopaedic Surgery and the American Orthopaedic Association".

On the third day, the members were taken to Omaha where a special clinical program had been arranged at the University Hospital by Dr. John P. Lord, Dr. Herman F. Johnson, and Dr. Robert D. Schrock.

The officers for 1937–1938 are as follows:

President: Frederick C. Kidner, M.D., Detroit, Michigan.
President-Elect: William Ward Plummer, M.D., Buffalo, New York.
Vice-President: Lloyd T. Brown, M.D., Boston, Massachusetts.
Treasurer: John L. Porter, M.D., Evanston, Illinois.
Secretary: Ralph K. Ghormley, M.D., Rochester, Minnesota.

The following Members of Committees and Delegates were elected:

Member of Membership Committee: A. R. Shands, Jr., M.D., Durham, North Carolina.
Member of Program Committee: William B. Carrell, M.D., Dallas, Texas.
Delegates to the American Board of Orthopaedic Surgery: Philip D. Wilson, M.D., New York, N. Y., and Frank R. Ober, M.D., Boston, Massachusetts.
Delegate to the American College of Surgeons: Wallace H. Cole, M.D., St. Paul, Minnesota.
Delegate to the Congress of American Physicians and Surgeons: J. Torrance Rugh, M.D., Philadelphia, Pennsylvania.

The following orthopaedic surgeons were elected to membership in the Association:

Joseph S. Barr, M.D., Boston, Massachusetts.
Robert E. Burns, M.D., Madison, Wisconsin.
Halford Hallock, M.D., New York, N. Y.
John R. Moore, M.D., Philadelphia, Pennsylvania.
Allen F. Voshell, M.D., Baltimore, Maryland.

The following foreign surgeons were elected as Corresponding Members:

Dr. François Petrus Fouché, Johannesburg, South Africa.
Dr. Dimitrije Yovtchitch, Belgrade, Jugoslavia.

Dr. Walter Truslow announces the removal of his office to the Medical Arts Building, 142 Joralemon Street, Brooklyn, New York.

The Sixty-Sixth Annual Meeting of the **American Public Health Association** will take place in New York City on October 5 to 8, 1937. Dr. Reginald M. Atwater is the Executive Secretary of the Association and the headquarters are at 50 West 50th Street, New York, N. Y.

The Twelfth Congress of the **Deutsche Gesellschaft für Unfallheilkunde, Versicherungs- und Versorgungsmedizin** will take place in Würzburg on September 24 and 25, under the presidency of Prof. Dr. Reichardt. A number of valuable papers bearing on this department of surgery will be presented and special attention will be given to the rôle of psychopathology.

Under the patronage of Her Majesty Queen Mary, the Seventh **English-Speaking Conference on Maternity and Child Welfare** was held in the Great Hall, British Medical Association House, Tavistock Square, London, on June 1, 2, and 3, 1937. The Rt. Hon. Sir Kingsley Wood, P.C., M.P. presided. As stated on the program, the theme of the Conference was: "The further evolution of the maternity and child-welfare movement throughout the British Empire and in the United States of America." Visits were also made to a number of maternity and child-welfare institutions.

The **Deutsche Orthopädische Gesellschaft** will hold its next Congress in Rostock on August 27, 28, and 29, under the presidency of Prof. Dr. Friedrich Scheel. The principal subjects to be discussed are: "The Relation of Orthopaedic Surgery to the Physical Development and the Military Efficiency of the German People" and "Diseases and Injuries in the Region of the Shoulder Girdle". These subjects will be discussed by men of prominence from different parts of Germany. There will be the usual social activities for the members and guests.

The **Internationaler Kongress für Kurzwellen in Physik, Biologie und Medizin** will be held in Vienna from July 12 to 17, under the patronage of Dr. A. d'Arsonval, His Excellency the Marquis G. Marconi, and Prof. Dr. J. Zenneck. Among the subjects to be discussed, the following are of orthopaedic interest: "Ultra-Short-Wave Therapy in the Treatment of Acute Infectious Diseases, Especially in the Treatment of Acute Poliomyelitis", and "Short-Wave Diathermy, Its Employment in Chronic Rheumatic Diseases of the Joints and the Muscles". Further information may be secured from the Secretary, Alserstrasse 4, Vienna, IX, Austria.

The next examination of the **American Board of Orthopaedic Surgery** will be held in Los Angeles on January 14 and 15, 1938, just preceding the meeting of the American Academy of Orthopaedic Surgeons. Applications must be in the Secretary's hands at least three months before the date of this examination.

The examination fee has been increased to $50.00, to correspond with that of the other specialty boards, this change of fee to take effect as of October 1, 1937. Applications received prior to October 1 will be considered on the present fee basis,—namely, $25.00

At the meeting in Atlantic City on June 7 and 8, certificates were granted to 104 candidates.

The annual International Symposium of Rheumatology, organized by the **Ligue Française contre le Rhumatisme,** will be held in Paris on October 9, 1937, under the presidency of Prof. Laignel-Lavastine. The clinical meeting will be held in the morning at Prof. Loeper's Clinic at the Hôpital Saint-Antoine. The afternoon will be devoted to the presentation and discussion of the following papers: "Radio-Active Treatment", by Dr. Coste, of Paris; "Emanotherapy", by Dr. Piery, Dr. Cluzet, and Dr. Milhaud, of Lyons; and "Radio-Active Effects Exerted by Thermal Waters", by Dr. Euziere and Dr. Castagne, of Montpellier. Requests for further information should be addressed to: Permanence de la Journée du Rhumatisme, 23, rue du Cherche-Midi, Paris.

The Fifth Annual Meeting of the **Western Orthopedic Association** will be held in Seattle on July 28, 29, and 30, with headquarters at the Washington Athletic Club. Officers are: Dr. Roger Anderson, Seattle, President; Dr. Vernon Thompson, Los Angeles, Secretary; Dr. Fraser Macpherson, San Diego, Treasurer. Dr. Sylvan L. Haas of San Francisco is President-Elect.

Dry clinics will be given on Wednesday morning, July 28, at the Children's Orthopedic Hospital under the supervision of Dr. H. J. Wyckoff and in the afternoon at the Harborview County Hospital under Dr. Donald Murray. The sessions on Thursday and Friday will include symposia on treatment of fractures of the hip, treatment of fractures of the spine, diagnosis and treatment of shoulder conditions, and treatment of the various types of foot disabilities. Operative clinics on Saturday morning, conducted by the Seattle doctors, will be under the direction of Dr. John LeCocq at the Orthopedic Hospital, and under Dr. Minor Lile at the Harborview Hospital.

In answer to the wide-spread demand for an agency which will attempt to certify competent surgeons, the **American Board of Surgery** was organized on January 9, 1937. This Board is a member of the Advisory Board of Medical Specialties which includes all of the boards of certification for the different medical specialties which have been already organized. Acting upon the invitation of the American Surgical Association, the following surgical societies cooperated in the creation of the American Board of Surgery: the American Surgical Association, the Surgical Section of the American Medical Association, the American College of Surgeons, the Southern Surgical Association, the Western Surgical Association, the Pacific Coast Surgical Association, and the New England Surgical Society. Two groups of candidates are recognized for qualification by the Board: (1) those who have already amply demonstrated their fitness as trained specialists in surgery; (2) those who, having met the general and special requirements exacted by the Board, successfully pass its qualifying examination. All applications for the first group (the Founders' Group) must be received within two years of the Board's organization. The Board will hold its first examination on September 20, 1937. Requests for information and application blanks should be addressed to the Secretary, Dr. J. Stewart Rodman, 225 South 15th Street, Philadelphia, Pennsylvania.

At recent Executive Committee Meetings of the **British Orthopaedic Association**, the following have been elected to membership:

Full Member

Mr. Arthur M. Connell, 18 Taptonville Crescent, Sheffield 10.

Associate Members

Mr. A. L. Eyre Brooke, Wingfield Morris Orthopaedic Hospital, Headington, Oxford.
Mr. W. S. Diggle, Walton Hospital, Liverpool.
Mr. W. A. Elliston, Children's Hospital, Longwood Avenue, Boston, Massachusetts, U. S. A.
Mr. D. Evans, 41 Newfoundland Road, Cardiff, Wales.
Dr. R. S. Garden, Northern Hospital, Liverpool 3.
Mr. W. Gissane, St. James's Hospital, London, S.W. 12.
Mr. T. V. Ley, Wagga Wagga, N. S. W., Australia.
Miss E. McComas, 29 Mary Street, Hawthorn, E 2, Victoria, Australia.
Mr. D. D. Pinnock, 57a Wimpole Street, London, W. 1.
Mr. J. W. M. Sutherland, 99 Clifton Road, Aberdeen, Scotland.
Mr. C. S. Walker, 17 Woodland Avenue, Wolstanton, Stoke-on-Trent.
Mr. J. Y. C. Yieh, Lester Chinese Hospital, Shantung Road, Shanghai, China.

Honorary Member

Dr. Paul Guildal, Orthopaedic Hospital, Copenhagen, Denmark.

Current Literature

A Manual of Radiological Diagnosis for Students and General Practitioners. Ivan C. C. Tchaperoff, M.A., M.D., D.M.R.E. (Camb.). With a Foreword by Philip H. Mitchiner, M.D., M.S., F.R.C.S. Baltimore, William Wood & Co., 1937. $6.00.

As indicated in the foreword by Mr. Mitchiner, this book furnishes a standard of comparison for the benefit of those desirous of observing such evidences of bone and soft-part pathology as are capable of being visualized by roentgenographic examination. After emphasizing in the introduction the absolute necessity for coordination of clinical studies with roentgenographic findings, if one is to arrive at a "reasoned reading" of a roentgenogram, the author proceeds, in Chapter I, to a brief technical consideration of what roentgenograms are, how they are generated, and what their effects are,—namely, fluorescent, photographic, and biological.

In Chapter II is taken up a general consideration of bones and joints: first, and briefly, from the normal standpoint; and, second, from a pathological standpoint. In these sections, as in the regional divisions of the subject, the reproductions, direct from the negatives, are well-nigh perfect, bringing out the pathology of the various lesions as they have not been shown in any text with which the reviewer is familiar. The descriptive text is no less illuminating than the pictures themselves.

In the regional section (Chapters III to VIII) a very complete presentation of the diseases common to the different anatomical divisions of the body, so far as they lend themselves to roentgenographic study, is set forth with an entirely adequate discussion. This includes the skull, the teeth, the spine, and all the rest of the osseous skeleton, the contents of the thoracic and abdominal cavities, the genito-urinary tract, the gall-bladder, the female generative organs and the foetus, and, finally, tumors of the spinal cord and ventriculography.

The whole work, beautifully done by the publishers and carrying an excellent index, is the most helpful guide to an understanding of x-ray pathology that has yet been presented.

Traité de chirurgie orthopédique. L. Ombrédanne et P. Mathieu. (En 5 Volumes.) Paris, Masson et Cie, 1937. Chaque tome, 300 francs; les 5 volumes, 1,500 francs.

This is an exhaustive work in five volumes, the first two of which have already appeared. In these volumes the two Directors have had the collaboration of sixty-one surgeons, chosen for their special training and experience in the subjects assigned to them. This treatise is essentially an exposition of the position of this department of surgery and of the work accomplished by the French orthopaedic surgeons, but the contributions and opinions of workers and investigators in other countries are fully recognized and accredited. Although the subjects are essentially orthopaedic, traumatology has been given a recognized position and its intimate relation and interwoven interests with orthopaedic surgery have received due prominence.

The scope of the subjects is planned to cover completely the field of orthopaedic surgery, with a full consideration of each topic and a presentation of the information which has resulted from recent investigations by those who are qualified for such special work.

Volume I presents the general physiology, pathology, and therapeutics of the component structures, especially of the bones, joints, muscles, tendons, and skin. Volume II deals with the nervous system and also includes the treatment of the sequelae of many of these diseases, particularly of the deformities resulting from infantile paralysis. Affections of the blood are next considered, followed by a discussion of the roentgenographic diagnosis in the treatment of sequelae of trauma. The second part of this volume is devoted to the spine and the upper extremity, and includes a discussion of the three

regions of the spine, with the affections found associated with them. This regional consideration is continued through the third, fourth, and part of the fifth volumes. Each portion of the body is considered, both as to the structures of the different parts and the conditions which are usually associated with them. The discussion of the generalities which precedes the pathology, clinical features, and treatment of each subject produces the impression of thoroughness and comprehensiveness.

It is seldom that we have a work so comprehensive in its scope with the details of each portion of the subject so accurately treated by those who are eminently fitted to give the most recent information. The reader is able to inform himself in a practical way on any phase of orthopaedic surgery, which would ordinarily be possible only by laborious consultation of an extensive amount of literature. The accurate subdivision into the related subjects leads the student to understand by what methods he should further conduct his investigation, and it also gives a good illustration of the interrelation of many of the subjects included in the constantly increasing scope of this specialty.

The two volumes already issued give indication of what may be expected from the following three. The books are beautifully bound and the quality of the printing is excellent. The illustrations are numerous, well selected, and of the same excellent quality which has always characterized the publications of Masson et Cie.

CHIRURGIE UND RECHT. DIE HAFTUNG DES CHIRURGEN UND DIE SICHERUNGSMASSNAHMEN IN DER PRAXIS. (Surgery and Law. The Liability of the Surgeon and Safeguards in His Practice.) Dr. med. Richard Goldhahn und Dr. jur. Werner Hartmann. Stuttgart, Ferdinand Enke, 1937. 11.80 marks.

To aid the surgeon in avoiding the pitfalls which land him in the courts of law, the authors have compiled a readable little manual of "do's" and "don'ts". They have explained the surgeon's responsibility in each phase of his practice and have abstracted many illustrative cases to emphasize the following important points: consent to operation, explanation of the nature of the operation, and the dangers connected with the operation itself. The loss of foreign bodies naturally occupies considerable space. The dangers connected with general and local anaesthesia, injections, and blood transfusion are outlined. There are chapters on conservative treatment and the omission or overdose of x-ray. The legal aspects of the surgeon's liability are briefly summarized in an appendix.

Presented as a timely warning, the book will probably be consulted more by those who are already in trouble. The principles involved are international, although the cases are from the German courts. There is a place for the volume in any medical library.

HANDBOOK OF ORTHOPAEDIC SURGERY. Alfred Rives Shands, Jr., B.A., M.D. In Collaboration with Richard Beverly Raney, B.A., M.D. St. Louis, The C. V. Mosby Co., 1937. $5.00.

The purpose of this handbook, as stated in the preface, is "to present for the consideration of the medical student and the general practitioner the fundamental facts and principles of orthopaedic surgery as concisely as possible and yet in sufficient detail to convey a well-rounded knowledge of the subject".

It is obvious that in a text of 500 pages it would be impossible to cover in detail the multitude of therapeutic measures that are used for orthopaedic disabilities. The diagnostic points and clinical pathology of practically all the more important orthopaedic disabilities are discussed in a concise and clear fashion. The illustrations are diagrammatic sketches and are to be commended for their simplicity and the clarity with which they convey the ideas intended by the author.

The specialist in orthopaedic surgery will probably find the book of little use, but for the medical student and the general practitioner it fulfills the need for that groundwork of information upon which they can build a more adequate knowledge of any particular disease process by reference to the bibliography.

Tumor und Unfall (Tumor and Injury). Erich Fenster. (Vorträge aus der praktischen Chirurgie, 14. Heft.) Stuttgart, Ferdinand Enke, 1937. 2.40 marks.

This booklet of thirty-two pages discusses the causal relationship between tumor formation and trauma as it occurs in medicolegal cases. One phase includes the injuries which are attributable more to a preexisting malignancy than to the factor of external trauma, as in spontaneous fractures.

In some instances, trauma has been shown to cause tumor formation in animals and in man. A predisposition to tumor formation must be assumed. The predisposition favors the presence of a germinal unit of tumor which occurs through an embryonic or degenerative disturbance of development; both may be either hereditary or acquired. In estimating the external factor which stimulates further tumor growth, it is important to establish a latent period (which in man is usually a matter of years), a certain continuity of "bridge" symptoms which characterize this latent period, and a coincidence between tumor site and point of outspoken injury.

Certain types of tumors may be more easily attributed to the influence of trauma than others, when degree and time relationship of the injury are sufficiently evident.

In attempting to determine a causal relationship between trauma and malignant tumor formation, histological proof of the nature of the tumor should be required. Roentgenograms should be taken at the time of injury, particularly in cases where bone is involved, with repetition over a period of time during which the indications given by the roentgenogram are important.

The final opinion in such medicolegal cases should be based on precise determination of fact and given by an arbiter who possesses the advantages of medical experience and the knowledge of pathology.

Elements of Orthopaedic Surgery. N. Ross Smith, M.B., Ch.M. (Sydney), F.R.C.S. (Eng.). Foreword by R. C. Elmslie, O.B.E., M.S., F.R.C.S. Baltimore, William Wood & Co., 1937. $4.00.

This is a useful book of nearly 250 pages, well illustrated, and well written. Its "aim . . . is to present a concise and practical account of the elements of orthopaedic surgery for practitioners and students . . . and for nurses and masseurs engaged in orthopaedic work." The purpose is good, but its accomplishment is well-nigh impossible to fulfill completely, because both the knowledge and the duties of its desired audience vary so greatly. Certain chapters—such as those dealing with the organization of welfare work for cripples (education, occupation, psychology), postural deformity, miscellaneous bone and joint disease, neoplasms, and fractures—are to be warmly commended. In the opinion of the reviewer, less praise can be given to certain of the other chapters dealing with specific defects, lesions, or diseases,—such as congenital deformities and rheumatic diseases. There seem to be fairly important omissions also,—for example, the extreme importance of early diagnosis of congenital dislocation of the hip by which all trauma commonly caused by manipulation may be avoided by the simple abduction treatment. Except for one sentence in the Appendix on Physiotherapy, the proved value of tank or pool treatment during the convalescent stage of poliomyelitis receives no mention. The very common lesions of the bursae, such as the subacromial or prepatellar, are not discussed.

Mr. R. C. Elmslie, the eminent orthopaedic surgeon of London, writes a preword to the volume, and there are three appendices. The author's diction is as admirable as is the publishers' make-up.

A Brief Outline of Modern Treatment of Fractures. H. Waldo Spiers, A.B., M.D. Ed. 2. Baltimore, William Wood & Co., 1937. $2.00.

This book of 133 pages attempts to illustrate the fundamentals of fracture surgery and to touch the high spots of treatment. It is important that this be done for the benefit of the undergraduate medical student and for the interne.

In general, the book is well written. Its very existence is significant of the tremendously increasing importance of the subject of fractures and dislocations. It is also significant that the author maintains the distinction between the subjects of orthopaedic surgery and the surgery of fractures. The book will be helpful to beginners in surgery.

TECHNIQUE OF UNDERWATER GYMNASTICS. A STUDY IN PRACTICAL APPLICATION. Charles Leroy Lowman, M.D., F.A.C.S., Susan G. Roen, Ruth Aust, B.S., and Helen G. Paull, B.S. Los Angeles, American Publications, Inc., 1937. $5.00.

The authors state that the purpose of the book is to assist those concerned with the practical application of corrective and therapeutic exercises in water.

Dr. Lowman and his associates present carefully studied and detailed information for building, locating, and maintaining the physical equipment of pools. The care required for properly locating pools is emphasized and its importance shown. The necessity for prevention of infection is stressed and methods for correction are described. The authors go into considerable detail in regard to the chemical study of the water used, but this is needed for the sake of completeness.

An important feature of the book is the description of charts for recording disabilities and their follow-up. The illustrations of treatment methods are excellent and the outline of the types of disease amenable to pool treatment is helpful.

The book should be of great value to anyone concerned with the supervision of distillation of a pool and is of importance to anyone directing pool activities.

DIE ATEMBEWEGUNGEN DER NORM UND FEHLFORM (Normal and Abnormal Respiratory Movement). Rudolf Dittrich. (Beilageheft zur Zeitschrift für Orthopädie, Bd. 65.) Stuttgart, Ferdinand Enke, 1937. 15 marks.

This book is a detailed study and presentation of the mechanics of respiration, based on the structures involved in the act of breathing and on a geometrical analysis of the part which each plays in this act. Although it is correlated with body metabolism and circulation, respiration is seen to be governed by physical laws.

The first section of the book is devoted to the variety of respiratory movements found in the normal individual—young and old, singer and athlete—with an explanation of the need for coordinate and rhythmic breathing to secure efficiency in bodily activity. Synergism between respiration and circulation is emphasized. Careful description is accorded prolonged exertion and the various phases of respiration which are initiated by the "warming-up" period.

In the second section, Dittrich gives a physiological basis to the school of psychotherapy which successfully treats a number of psychic disorders by regulation of breathing. Analysis and treatment of abnormal respiratory movements are given for cases of deformity of the thoracic cage and of the vertebral column. An example of Dittrich's detailed analysis is found in his explanation of the frequent association with scoliosis of nasal obstruction, high palate, and mouth-breathing.

The last portion of the book deals with the technique of methods of examination, including x-ray kymography and x-ray cinematography.

"Atembewegungen der Norm und Fehlform" is a new and thorough contribution to the physiology of respiration and a valuable reference book in this field.

LIBRE JUBILAIRE OFFERT AU DOCTEUR ALBIN LAMBOTTE *PAR SES AMIS ET SES ÉLÈVES.* Brussels, Vromant & Co., 1936.

This volume of over 500 pages, profusely illustrated, was completed by the friends and former students of Dr. Lambotte. The list of collaborators constitutes a short catalogue of well-known orthopaedic surgeons throughout the world. The contributions consist mainly of short summaries of the work of each surgeon, printed in his native tongue. Taken all in all, they present an excellent and concise statement of the main osteosynthetic procedures at present employed throughout the world. Dedicated as

they are to the father, or the arch proponent, of the operative treatment of factures, it is but natural that these articles should form an enthusiastic tribute to the method as well as to the man who did most to establish the method. Several interesting addresses by Prof. Hustinx, Prof. Sauerbruch, and Prof. Leriche serve as introductions to the volume. Of these, the last, a discourse on "The Future of Bone Surgery", is a masterful piece of writing. Considering bone surgery from a broad biological point of view, it is a stimulating tribute, laid reverently at the feet of a great master by another great master and friend.

Health and Muscular Habits. Lieut.-Colonel J. K. McConnel, D.S.O., M.C., and F. W. W. Griffin, M.A., M.D. London, J. & A. Churchill Ltd., 1937. 5 shillings.

The authors, with a competent understanding of kinesiology, have put into non-technical phraseology an explanation of the mechanics of movement in the activities of daily life. No attempt has been made to consider deformities or cases needing medical care. It is the aim of the book to make the individual aware of the mechanics involved in normal motions and to recognize and to correct faulty movements, thereby forming new and correct habits.

Balance of the pelvis, reciprocal muscle action, breathing, tasks of the abdominal, back, and pectoral muscles, and the feet are given consideration. Following each chapter explaining the working of the various parts is a section devoted to an analysis of faulty use and instruction in methods of correction. One can readily recognize in the descriptions of poor mechanics the insidious habits which, becoming fixed, cause poor posture, and one can realize how ineffectual exercise periods and special exercises will be unless these habits are corrected.

This book can be recommended to doctors and physiotherapists as a workable volume, and to the individual who wishes to become mechanically efficient as within his scope and appealing to his intelligence.

Diabetes und Chirurgie. A. W. Fischer. (Vorträge aus der praktischen Chirurgie, 12. Heft.) Stuttgart, Ferdinand Enke, 1937.

In this booklet of twenty-eight pages are discussed briefly the surgical problems presented by the diabetic patient. The author emphasizes the facts that some manifestations of latent and active diabetic coma may be confused with symptoms of peritonitis, and the regression of leukocytosis under antidiabetic treatment in the presence of glycosuria differentiates the condition from a true peritonitis in which a leukocytosis is uninfluenced by antidiabetic treatment.

Surgery in a diabetic is absolutely contra-indicated by a blood sugar of 350 milligrams per 100 cubic centimeters and a carbon dioxide combining power of less than 40 volumes per cent. Improvement of such a condition by insulin, glucose, and, if necessary, a 5-per-cent. solution of sodium bicarbonate given intravenously permits operation within two to three hours. Where operation is not urgent, at least a week should be given to preoperative preparation, with sufficient carbohydrate to restore depleted glycogen.

In the matter of accident insurance, it is necessary to determine that diabetes and not merely an initiating injury is the determining cause of the consequences.

The surgical treatment of localized infections and gangrene attributable to diabetes is well discussed. The author advocates radical methods aided by evipan and electrosurgery.

Surgical Treatment. A Practical Treatise on the Therapy of Surgical Diseases. James Peter Warbasse, M.D., F.A.C.S., and Calvin Mason Smyth, Jr., B.S., M.D., F.A.C.S. 3 Vols. Ed. 2. Philadelphia and London, W. B. Saunders Co., 1937. $35.00.

There have been a number of single volumes or systems of surgery during the past few years and this second edition of a three-volume set devoted to surgical treatment does not necessarily add a great deal to the sum total of accessible knowledge of the subject. The manner of the classification and arrangement of the sections leaves much to

be desired. From the standpoint of the specialist, the plan would not be at all desirable, and the general surgeon or physician might find it inconvenient also. This text is written primarily for the physician in general practice or the general surgeon, and the arrangement may be more satisfactory from their standpoint. The material is made more readily accessible by the inclusion of a separate Index volume.

This second edition represents a revision of each section. Most significant changes are those in the chapters on blood transfusion and the management of the syphilitic patient, and there is a marked enlargement of the chapter on physical therapy such as light, heat, electricity, x-ray, and radium. Fracture treatment has been considered primarily from the standpoint of fundamental principles and, while some of the newer methods and the apparatus recommended for their execution have been described, the authors have selected at least one method which they themselves prefer and have given this in detail so that any doctor who possesses the mechanical natural skill essential for the successful management of fractures can carry it out.

The text is simple, concise, easy to read, and well illustrated with anatomical drawings. In the Foreword the authors state that "Surgery is an art based upon a complex of sciences". For this reason they have suggested various procedures as a stimulus to the originality of the reader. Throughout the three volumes many of the illustrations have been simplified in the form of diagrammatic line drawings which help to make clear the surgical principles and procedures described.

Sections of the book dealing with first aid to the injured, bandaging, and minor surgery should be especially welcome to the doctor in general practice whose problems have to be dealt with in his own office.

These three volumes could be recommended as a text for students and as a source of reference for the general surgeon. The set is as complete, accurate, and up to date as any work of a similar nature published in the English language.

The Journal wishes to acknowledge the receipt of the following publications sent to the Editorial Department:

*Die Anatomie der angebornenen Hüftverrenkung. V. Putti. Stuttgart, Ferdinand Enke, 1937.

*Fracturas y Luxaciones. Terencio Gioia. Tomo II. Buenos Aires, Aniceto Lopez, 1934.

*Short-Wave Diathermy. Tibor de Cholnoky. New York, Columbia University Press, 1937.

*La spondylolyse et ses conséquences. Spondylolisthésis; scoliose listhésique. P. Glorieux et C. Roederer. Paris, Masson et C^ie, 1937.

Anales del Servicio de Traumatología, Cirugía Ortopédica y Accidentes del Trabajo del Hospital Provincial de Valencia, III, Núms, 31–36, 1936.

Bethesda (Pittsburgh, Penna.), XXXIX, No. 2, 1937.

Bollettino e Atti Reale Accademia Medica di Roma, LXII, Fasc. 7–10, 1936.

Bulletin of the National Tuberculosis Association, XXIII, Nos. 4, 5, and 6, 1937.

The Bulletin of Westchester County Division Podiatry Society of the State of New York, March, April, and May, 1937.

Central Council for the Care of Cripples (National Council for Maternity & Child-Welfare). Report for the Year 1936. London, 1936.

The Child (Washington, D. C.), I, Nos. 9, 10, 11, and 12, 1937.

Cleveland Clinic Quarterly, IV, No. 2, 1937.

Die Entwicklungsstörungen der menschlichen Gliedmassen. Fehler im Bereich der Gliedmassen bei sog. systemisierten Missbildungen des Bewegungsapparates. 7. Die multiple angeborene Gelenkstarre. 8. Pleonosteosis familiaris (Léri). B. Valentin. Jena, Gustav Fischer, 1937.

Journal de Médecine de Bordeaux et du Sud-Ouest, CXIV, Nos. 8–9, 1937.

Radiography and Clinical Photography, XIII, No. 1, 1937.

* To be reviewed in a subsequent issue.

Roche Review, I, Nos. 8 and 9, 1937.
The Rotarian, L, No. 6, 1937.
"Solvitur Ambulando." A Symposium on Prosthetic Achievement. London, J. E. Hanger & Co. Ltd., 1937.
University of Pennsylvania Bulletin. Graduate School of Medicine, Announcement for Session 1937–1938. Philadelphia, 1937.

KURZER ÜBERBLICK ÜBER PATHOLOGIE UND KLINIK DER BIZEPSSEHNENRUPTUREN NEBST EINIGEN EIGENEN FÄLLEN (A Brief Summary of the Pathology and Clinical Findings in Rupture of Biceps Tendon with Case Reports). Torsten Björkroth. *Acta Chirurgica Scandinavica*, LXXIX, 280, 1937.

Because of its intra-articular course, the long head of the biceps is predisposed to rupture as a result of arthritic and periarthritic changes in the shoulder joint. Six cases of this lesion are reported in detail with two cases each of rupture of the short head and of the common tendon of the biceps. Dislocation of the shoulder predisposes to rupture of the biceps. In old individuals it may be this lesion and not chronic arthritis which causes disability.

Good results were obtained in four cases of rupture of the long head by looping the tendon through a tunnel at the base of the greater tuberosity.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

STILLSCHE KRANKHEIT UND TUBERCULOSE (Still's Disease and Tuberculosis). Halfdan Sundt. *Acta Orthopaedica Scandinavica*, VII, 205, 1936.

To establish the diagnosis of Still's disease, it is necessary to have at some time during the illness the cardinal symptoms of polyarticular swelling, polyadenitis, and enlargement of the spleen. Remissions may last for several years. Most opinions attribute the disease to chronic infection with staphylococci or streptococci. A few writers think that it may be produced by different arthrotropic viruses, including the tuberculous virus.

Two true cases of Still's disease are reported in detail in which tuberculosis was the probable cause. Both patients were males. In one, the onset was at the age of seven with acute polyarthritis, high fever, and severe pain. Three years later fluid from the right subacromial bursa was proved tuberculous by guinea-pig inoculation, and an excised cervical lymph gland, by histological examination. Post-mortem examination showed extensive tuberculous involvement of lymph glands, peritoneum, pericardium, and pleura, but chronic villous synovitis without gross evidence of tuberculosis. In the other case, the onset was at thirteen months as an acute polyarthritis. When the patient was seen seven years later, there was typical involvement, including symmetrical tenovaginitis of the hands and feet. Injection of tuberculin produced an indisputable focal reaction in the tendon sheaths at both wrists. Extirpated sheaths were negative histologically for tuberculosis.

The writer attributes the characteristic findings in these cases to tuberculous infection and the non-specific changes in the synovial membrane in one and the tendon sheaths in the other to a particular allergic reaction.

He suggests that enlargement of the lymph glands, liver, and spleen may occur to a lesser degree or as a transitory phenomenon in various forms of chronic polyarthritis as a result of some special constitutional condition (lymphism). This particular way of reacting to the infection need not constitute a distinction between Still's disease and other types of chronic polyarthritis of childhood.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

TREATMENT OF TUBERCULOSIS OF THE ELBOW BY RESECTION AND ARTHROPLASTIC OPERATION IN ONE SEANCE. Ragnar Magnusson. *Acta Orthopaedica Scandinavica*, VII, 325, 1936.

Combined resection and arthroplasty was performed in seventeen cases of tuberculosis of the elbow. Abscesses and fistulae were cleaned up at the time of the operation

and were not considered a contra-indication. The synovia and all tuberculous material were cut away and a piece of fascia lata was inserted. Motion was started in from two to three weeks and resistance exercises soon thereafter. Massage was not given.

Follow-up examinations or questionnaires in sixteen cases showed ankylosis in one and mobility in the remainder. Twelve patients were able to work as maids and seamstresses, and one patient, as a timber floater. All wounds remained healed after the patients left the hospital except for one case in which a fistula formed. Only four patients had occasional pain. The results were better in the cases operated on early in the disease.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

Zur Kenntnis der Meniskusganglien im Kniegelenk (Ganglia of the Semilunar Cartilages of the Knee). E. Norinder. *Acta Orthopaedica Scandinavica,* VII, 362, 1936.

Five cases of ganglia of the semilunar cartilages are reported,—four of the lateral cartilage (one bilateral pair), and one of the medial. The diagnosis had been made by palpating the ganglion. The symptoms were relatively slight with no locking. The lesion of the medial cartilage was in connection with a tear and the cartilage was removed. Three of the ganglia of the lateral cartilages were operated upon. The tumors were removed but the cartilages themselves were not disturbed. The symptoms were relieved.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

Chordoma. Van D. Barnes and Seward E. Owen. *The American Journal of Cancer,* XXIX, 541, March 1937.

The authors report a case of sacrococcygeal chordoma in a male patient of fifty-nine, confirmed by biopsy and roentgenogram, in whom x-ray treatment afforded partial symptomatic relief. They have encountered four cases of chordoma in 4000 admissions of males for cancer treatment at the Veterans' Administration Clinic, Hines, Illinois. There is a brief review of the literature and a full report of the case with autopsy findings. Assays of urinary prolan showed a small amount on several occasions, rising at the time of the patient's last visit to 1000 mouse units per liter. No physiological explanation for these findings is offered.—*Grantley W. Taylor, M.D., Boston, Massachusetts.*

Osteogenic Sarcoma of the Femur in a Guinea-Pig. S. A. Leader. *The American Journal of Cancer,* XXIX, 546, March 1937.

The author adds a case of osteogenic sarcoma of the femur to the twenty recorded instances of spontaneous tumors in guinea-pigs. This guinea-pig, of unrecorded ancestry, presented pulmonary metastases. Numerous photographs and two photomicrographs confirm the character of the tumor.—*Grantley W. Taylor, M.D., Boston, Massachusetts.*

Ossifying Fibroma of the Maxillary Sinus: Report of a Case Successfully Treated with Irradiation. Isidore Arons. *The American Journal of Cancer,* XXIX, 551, March 1937.

The author reports a case of ossifying fibroma of the antrum in an eleven-year-old boy, successfully treated with large doses of radium and x-ray. He emphasizes the benign character of this neoplasm, and accounts for the methods of treatment employed by the fact that the original pathological diagnosis was mistakenly osteogenic sarcoma. He concludes, however, that ossifying fibroma may be successfully treated by radiation alone.

Photographs and roentgenograms illustrate the report. The photograph of the patient ten years after treatment shows some facial asymmetry and a marked radiation change over the entire cheek.—*Grantley W. Taylor, M.D., Boston, Massachusetts.*

PAGET'S DISEASE ASSOCIATED WITH HYPERNEPHROMA. Herman Charache. *The American Journal of Cancer*, XXIX, 729, Apr. 1937.

The author reports with roentgenograms and photomicrographs a case of coincident Paget's disease of the skeleton and hypernephroma with multiple skeletal metastases. The patient was a male, sixty-three years old, whose symptoms were chiefly due to the metastases involving the tibia. Roentgenographic findings disclosed characteristic appearances of both pathological conditions. Autopsy confirmed the clinical diagnoses.—*Grantley W. Taylor, M.D., Boston, Massachusetts.*

MYOSITIS OSSIFICANS. M. H. Hobart. *American Journal of Surgery*, XXXIV, 227, 1936.

The author classifies two types of this condition described as deposition of bone in muscles or about their insertions,—namely, progressive, which usually begins in the muscles along the spine and gradually spreads to all muscles of the body with interference with respiration, and the circumscribed, which is usually confined to one muscle or locality, and, if caused by trauma, may spread more rapidly to reach its maximum degree of involvement.

The theories as to the cause are implantation of periosteum in muscle, or the escape of osteogenic cells from the periosteum, or ossifying hematoma, or metaplasia. It is usually considered that trauma—either mild or severe, in the form of repeated injury, dislocations about a joint, or variations in the treatment of fractures—is a factor in all cases. The more common sites are the brachialis anticus and the quadriceps femoris muscles.

From the pathological standpoint, there is a degeneration of muscle fibers, with infiltration of fibrous tissues, cartilage cells, and normal appearing bone, which may, or may not, be attached to the bone beneath. The usual symptoms are interference with function, less often pain, and a mass in the muscle becoming larger and firmer, with roentgenographic evidence of shadow, usually seen three or four weeks after injury.

Prognosis is generally good except in cases in which a joint is involved; if such cases are neglected or improperly treated, interference with function may result. Early treatment usually consists of rest, preferably in a cast; in the case of the elbow, stress is laid upon the flexion position to prevent the formation of a mass in the cubital fossa. By the time the diagnosis is made, heat is usually indicated either in the form of diathermy or hydrotherapy. Surgical interference is indicated only if pain is continued or if function is interfered with, and, in some instances, in order to differentiate from tumor. Quiescent cases should not be disturbed.

Nine cases are reported in detail.—*Custis Lee Hall, M.D., Washington, D. C.*

GRIDDING THE FEMORAL HEAD AND NECK AREA IN FRACTURE OF NECK OF FEMUR FOR SIMPLER GUIDANCE AND PLACEMENT OF THE SMITH-PETERSEN THREE-FLANGED NAIL. Michael S. Burman. *American Journal of Surgery*, XXXIV, 237, 1936.

The author describes his method of plotting the direction of Kirschner wires for the placement of the Smith-Petersen nail.

After the fracture has been reduced, "a Kirschner wire is placed on the skin in the line of the head and neck of the femur at an eye-estimated angle of 115 degrees to 125 degrees and two parallel wires about one-quarter of an inch apart are placed above the first wire and two below. A field is thereby gridded out which includes the entire head and neck area of the femur." A roentgenogram is then taken, which shows the position of the head and neck of the femur, the fracture, and the trochanter in relation to the wires. In this way the placement of the nail may be determined. With this group of wires as a guide, two wires are placed in the bone parallel to the skin wires. These wires placed in the bone are then identified on the film and the one selected as being best placed is used as a guide for the nail.

This method may prove of help to those who have not as yet worked out and used

their own method or modification of determining the angle and depth of the wire. The advantages of the author's technique are simplicity and lessening of the time necessary in the placement of the wire as a guide.—*Custis Lee Hall, M.D., Washington, D. C.*

OSTEOSCLEROSIS (TRAUMATIC) OF CARPAL BONE. A SUGGESTION AS TO TREATMENT. Lewis Clark Wagner. *American Journal of Surgery*, XXXIV, 357, 1936.

Eight cases of osteosclerosis of the carpal, semilunar, and scaphoid bones are reported and classified as Kienböck's disease. As to the etiology of the condition, two acceptable theories are mentioned: (1) paroxysmal angiospasm, with local ischaemia, followed by local necrosis; and (2) a traumatic axon reflex, described by Leriche, with vasoconstriction and vasodilatation, hyperaemia, and resulting bone absorption. This is a preliminary stage to bone death and vascular obliteration.

There have been reported in the literature a large number of cases of fracture and non-union of the carpal scaphoid in which, following the use of a bone graft, roentgenographic examination showed retrabeculation. The author reports a series of cases, treated by bone grafts and drilling, with roentgenograms indicating regeneration of the trophic and sclerosed bone in the carpal region, absorption of the grafts between the articular surfaces of the reconstructed carpal bones, and marked diminution of symptoms of pain and stiffness, with improved function. Postoperative roentgenograms showed restoration of the normal appearance of the carpal bones.

Several authors have obtained similar results by simply drilling the fragments, allowing revascularization. There is no doubt that drilling alone, or drilling and grafting, gives far better end results than the excision of even small portions of the affected carpal bone, which, as an operative procedure in this type of condition, should be discarded in favor of bone grafting or drilling, or both.—*Custis Lee Hall, M.D., Washington, D. C.*

RUPTURES AND TEARS OF MUSCLES AND TENDONS. H. Earle Conwell and R. H. Alldredge. *American Journal of Surgery*, XXXV, 22, 1937.

Injuries to the muscles and tendons have previously been considered rare, but, undoubtedly, many cases have been overlooked due to incomplete study and examination and the likelihood of diagnosis as sprain or bursitis, when the actual condition is a tearing of muscles and tendons.

From the etiological standpoint, the authors group these injuries according to the classification of Gilcreest, due primarily to senility, pathological changes, physiological predisposition, occupational injuries, fatigue, and trauma.

In the order of frequency, the most common sites of injury are the muscles of the calf, the extensors of the leg, the biceps tendon, and the Achilles tendon. Many of these cases can be treated conservatively if the lesion is not too serious to allow healing to take place, without permanent dysfunction. Operative procedure is indicated in the cases in which gross changes are found. Treatment should consist of immobilization for a period of from two to three weeks in the cases of partial rupture, and for a longer period in the operative cases, depending upon extent and location of the lesion, the healing muscle being placed entirely at rest following operative repair.

The authors report eleven cases. The etiological factors and the diagnostic methods are well described, and the article is illustrated to show the characteristics of the more common varieties. The injuries occur more frequently in middle-aged individuals in whom the weakening of muscles and ligaments, associated with stress and strain, causes the injury. They can best be diagnosed by careful examination, with particular reference to localized pain, loss of function or painful function, or a defect in the muscle or tendon, with or without ecchymosis.—*Custis Lee Hall, M.D., Washington, D. C.*

ORGANIC CALCIUM IN HEALING OF FRACTURES. Greshom Downs. *American Journal of Surgery*, XXXV, 34, 1937.

From an experimental study of the relation of calcium to the healing of fractured fibulae in rats, the author found that the fractures healed more readily when the animals

vere on a diet in which protein was present in abundance and in which the calcium and phosphate were present in adequate quantities and proper ratio. An organic calcium phosphate was used in these studies and it is suggested that it was more readily and more completely metabolized than inorganic forms of calcium. However, there was not a great deal of variation noted after the feeding of the two types of organic calcium salt, but that obtained from the cereal, Indian Corn, was utilized more readily by the organism than that from milk. Weight gains of the animals were observed during the course of the experiment and, from the breaking-strength test of the healed fibulae and from the histological studies, more rapid and complete healing was noted. The blood studies were negative except that calciphos caused more rapid clotting of the blood, indicating the value of further work in this direction.—*Custis Lee Hall. M.D., Washington, D. C.*

Acute Suppurative Tenosynovitis of the Flexor Tendon Sheaths of the Hand. A Review of One Hundred and Twenty-five Cases. Robert S. Grinnell. *Annals of Surgery*, CV, 97, Jan. 1937.

Infection of the tendon sheath may occur from one of four routes,—puncture wound (primary), extension from a neighboring infection (secondary), blood stream, or lymphatic spread. None of the cases in this series were due to lymphatic or blood-stream infection, except seven gonococcus infections which are discussed separately.

There were sixty-seven primary and fifty-eight secondary cases. All gave a history of trauma. In 47 per cent. the wound was near or in the flexor crease. The distal crease alone was involved in forty-one cases. The next most common site was the distal closed space (twenty-three cases). The right hand was involved twice as often as the left, and the digits were affected in the order named: second, third, first, fourth, and fifth.

Early diagnosis is essential. The average delay in operation, because of error in diagnosis, was one day in the primary group and four days or more in the secondary group. Diagnosis is based on tenderness localized to the region of the sheath, flexion deformity in the digit, exquisite tenderness on extension of the distal phalanx, and a wound of entry. In the secondary group, diagnosis is more difficult. Infection outside the sheath confuses the picture, and it is difficult to determine whether or not the sheath has been invaded when a localized portion of the sheath only is involved.

End results, based on a follow-up of sixteen months, were discouraging. Over one-third of all cases fell into Group I (bad) and nearly two-thirds belonged in Groups II and III (fair, good). Only one-sixth of the patients regained approximately full function.

Gross sloughing of the tendons in whole or in part occurred in 52 per cent. of the cases.

The streptococcus hemolyticus was the infecting organism in 36 per cent. of the cases and the staphylococcus in 31 per cent. The remaining cases were not cultured, or mixed infections were found. The results were better in the staphylococcus infections. Tendon slough was about equal in the two types of infection, but much higher in the mixed infection.

The radial bursa was involved thirteen times, the ulna eight times, and both were affected in ten instances. In all but one case the spread was from the radial bursa. In only one case was the digital sheath of the thumb involved without extension to the radial bursa. The thenar space was involved in fifteen cases; the midpalmar, in four, the forearm, in nine; and the wrist joint, in one. Extension from the volar to the dorsal surface occurred ten times. There was one death, and the prognosis was definitely poorer with advancing age. There were three arm and eight finger amputations. Osteomyelitis occurred in 38 per cent. of the cases; the middle phalanx was most often involved.

The average time from operation to complete healing was fifty-three days. Delay before operation and incomplete drainage are probably the most important causes of poor results.

Treatment: Incisions were usually multiple, short, anterolateral, bilateral or uni-

lateral, over the proximal and middle closed digital spaces, and a single midline incision over the sheath in the palm. The latter is recommended whenever the digital sheath is involved. The bursae above the wrist were usually drained by lateral incisions, as advocated by Kanavel. Digital incisions, lateral to anterior vessels, were not used, as interference with sheath and tendon nutrition was feared. Truncated finger flaps, as suggested by Auchincloss, are recommended,—one for the proximal and one for the middle closed spaces. The distal end is cut along the flexion crease and the sides are cut obliquely to avoid the anterior vessels and nerves, including all tissues down to the tendon sheath, and extending nearly to the next proximal crease. This method affords better drainage. Sterile wet dressings of saline or boric solution postoperatively give better results than hot soaks.

In the seven cases of hematogenous gonococcal tenosynovitis, healing occurred in twenty days. There was no sloughing of the tendons, and the results were almost uniformly good.—*N. T. Kirk, M.D., San Francisco, California.*

ADAMANTINOMA OF THE JAW. Robert H. Ivy and Lawrence Curtis. *Annals of Surgery,* CV, 125, Jan. 1937.

Adamantinoma is a tumor derived from the enamel-forming cells of the dental epithelium, usually characterized by multilocular cystic formation, or it may be a solid tissue tumor in its early stages. Calcification or enamel formation, as the name implies, is never seen. The molar region of the mandible is most frequently involved. The cortical bone becomes distended and may become perforated. The cystic cavities are lined with cuboidal cells and filled with viscid, brownish fluid; in the fibrous tissue or bone surrounding them, columnar cells are found, having the histological characteristics of the enamel organ (ameloblasts). The tumor occurs at any age and is not considered malignant, although it tends to recur locally.

It produces a painless swelling, slowly increasing in size in the alveolar process; the outer plate usually shows more involvement than the inner. The tumor is lobulated in form and, when the overlying bone becomes thinned, it feels elastic on pressure. Roentgenograms show the growth divided into compartments by fine bony trebeculae. Occasionally it is impossible before operation to differentiate this tumor from giant-cell tumor, osteitis fibrosa cystica, sarcoma, or metastatic growths. The clinical course of the aberrant dentigerous cyst very closely resembles that of adamantinoma, so that for practical purposes of treatment it is just as well to regard them as one and the same.

Treatment: Complete removal of the abnormal epithelium is essential, or recurrence follows. Enucleation and curettage, when the tumor is small and surrounded by well-defined bony walls, occasionally results in cure. This may be supplemented by radium implantation. Recurrence is not infrequent.

When the tumor is large, extending into surrounding bone or soft parts, complete resection should be the initial treatment followed by bone transplantation.

Sixteen cases are reported, three in detail. In fifteen the mandible was involved and in one the maxilla was affected. Four were treated by conservative enucleation; two, by enucleation and radium; five, by primary resection; and five, by secondary resection for recurrence after enucleation.—*N. T. Kirk, M.D., San Francisco, California.*

UNUNITED FRACTURES OF THE SHAFT OF THE HUMERUS. Willis C. Campbell. *Annals of Surgery,* CV, 135, Jan. 1937.

Fifty cases of non-union are reported, forty-nine of which were treated by massive onlay grafts; bony union was obtained in 93.8 per cent. One long oblique fracture united after fixation by autogenous bone nails.

Delayed union and non-union occur more frequently in the humerus than in any other long bone, due to the fact that complete immobilization by external apparatus is impossible. Of 226 ununited fractures treated by massive grafts, fifty-three were in the

tibia, thirty-two in the femur, fifty-two in the humerus, and eighty-nine in the forearm. In 4000 fresh fractures of shafts of long bones the distribution was: leg, 1066; femur, 758; forearm, 1883; humerus, 293.

Operative technique: All scar and fibrous tissue is removed from the fragment ends, the medulla is reamed out, and just as little periosteum is stripped as is necessary, leaving attached the blood supply. The fragments are flattened with a chisel, and "shavings" are removed for the graft "bed". A broad, flat, massive graft is taken from the opposite tibia, with "sufficient length, breadth, and dimension to secure firm fixation". The graft is split longitudinally with a motor saw into an outer cortical plate and an inner or endosteal plate. A strip of the latter is placed in the medulla and the rest used as chips about the fracture. The outer plate is secured to the flattened humerus by autogenous bone nails driven into four or more drill holes. The bone nails are made from a separate graft, or part of the original outer plate is used. A rotary file, attached to the motor saw, and a metal gage are used to make them. Spongy bone from the head of the tibia is removed by a sharp bone curette and added about the fracture site. A cast is applied from the rib margins, over both shoulders, to the knuckles of the affected arm.

Twelve cases were operated on within four months after the original injury, and there were no failures; thirty-eight cases were operated on after four months with three failures.—*N. T. Kirk, M.D., San Francisco, California.*

THE APPLICATION OF COBRA VENOM IN MODERN MEDICINE. J. Singh Chowhan. *The Antiseptic*, XXXIV, 273, 1937.

The author states that the use of cobra venom is reported to have relieved the pains of sciatica and severe neuralgia. "In specific non-rheumatoid arthritis, . . . there was a strong decrease in the swellings of the joints particularly in the gonorrhoeal and tuberculous processes, together with relief of pain." Fifteen cases of arthrosis of the knee, shoulder, or spine were treated, with marked analgesic effect and considerable subsequent functional improvement.—*Robert M. Green, M.D., Boston, Massachusetts.*

CHONDROMATOSIS OF THE JOINTS. Ernst Freund. *Archives of Surgery*, XXXIV, 670, Apr. 1937.

Freund takes exception to Lexer's theory that chondromatosis of joints represents a tumor growth of the synovial membrane. Instead, he considers this a metaplastic hyperplasia of the connective tissue, with chondral predominance, but also with calcification and bone formation. He believes the condition is analogous to myositis ossificans, even to the similarity in spontaneous resorption when the secondary irritative factors are removed by immobilization. He offers no explanation for the etiology, but describes in full three cases which he has studied.—*I. William Nachlas, M.D., Baltimore, Maryland.*

USE OF HOMOLOGOUS BONE GRAFTS IN CASES OF OSTEOGENESIS IMPERFECTA. Alan DeForest Smith. *Archives of Surgery*, XXXIV, 686, Apr. 1937.

The author reports the correction of deformities in osteogenesis imperfecta by the use of homologous bone grafts.

The grafts in these cases are considered merely scaffoldings for the new bone to grow on so that the fact that they are taken from the parents or from strangers, or even that one of the grafts was placed in a sterile test tube and refrigerated for several weeks prior to the second operation, makes no difference in the use of the grafts.

He reports four cases treated in this manner, with successful results.—*I. William Nachlas, M.D., Baltimore, Maryland.*

REFLEX DYSTROPHY OF THE EXTREMITIES. Géza de Takáts. *Archives of Surgery*, XXXIV, 939, May 1937.

The author calls attention to the reflex dystrophy occasionally seen in extremities which have sustained mild traumata or infections or injuries to the vascular system, and describes five such cases which he has observed. The essential findings in the patients

are: (1) a hard, non-pitting oedema; (2) bone changes, consisting of a spotty atrophy, retarding of growth, and premature closing of the epiphyses; (3) sensory changes, characterized by increased sensitivity to temperature changes and pressure and localized hyperaesthesia; (4) vasomotor disturbances, with a glossy skin, changes of skin temperature, overgrowths of hair, and eczema; (5) muscle hyperirritability or atony; (6) brittle and ribbed nails; and (7) contracted joint capsules, giving painful motion.

The disturbances are produced by a chronic irritation which sends impulses through the sensory nerves to the cord where they are relayed to the lateral horn and stimulate the efferent sympathetic nerves to the extremity. This reflex is accentuated by the removal of cerebral inhibitions as in mentally unstable or defective persons.

The treatment recommended consists of breaking the arc by excision of the irritant or by sympathectomy.—*I. William Nachlas, M.D., Baltimore, Maryland.*

ASEPTISCHE KNOCHENNEKROSE IN DER PATELLA (Aseptic Bone Necrosis in the Patella). Paul Rostock. *Bruns' Beiträge zur klinischen Chirurgie*, CLXIV, 177, 1936.

The author reports a case of aseptic necrosis of bone in the patella of a forty-year-old man, who sustained a slight injury to the knee. Five days after the injury a lateral roentgenogram revealed a longitudinal rarefaction in the lower pole of the patella, extending upward from just above the lower border of the patella. Within this zone of rarefaction lay a very fine, but well-defined, needlelike sequestrum. Three weeks later this focus was removed. Histological section from the sequestrum bed revealed marked hypertrophy of the media and intima of the vessels, with almost complete obliteration of the lumen and definite reactive changes. No bacteria were present. The slight trauma could not have produced these changes within five days.

The author has observed four other similar cases which he previously described as "osteopathia patellae". He finds only three cases in the literature.

The two cases which Gellman has described as osteochondritis dissecans of the patella are "partite patella" according to the author.—*Harold Unger, M.D., Iowa City, Iowa.*

UN CAS DE LA MALADIE DE SVEN JOHANSSON-SINDING LARSEN. Willy Smets. *Bulletin de la Société Belge d'Orthopédie*, VIII, 163, 1936.

This is a name given to an osteochondritis of the lower end of the patella. It seems to the author unfair to make a morbid entity of this condition. The symptoms are not characteristic of simple traumatic lesions which produce a certain roentgenographic picture at the lower end of the patella. It is essentially an abnormal process of osteogenesis at the point of the patella, which may be grouped with the other disturbances of endochondral ossification, such as Köhler's disease, etc.

Clinically, it is characterized by painful phenomena at the point of the lower end of the patella, and it occurs in children between the ages of nine and fourteen. The author also maintains that the roentgenographic changes simply denote a normal stage of the ossification of the patella. One case is reported.—*Arthur Steindler, M.D., Iowa City, Iowa.*

OSTEOMYELITIS AND SUPPURATIVE JOINTS: SALT WATER POOL TREATMENT. A. Brockway. *California and Western Medicine*, XLVI, 174, March 1937.

The author discusses the salt-water-pool treatment of acute suppurative arthritis, acute osteomyelitis with suppuration of the adjacent joint, and osteomyelitis in which the disease closely encroaches upon a joint structure. He reports thirty cases and shows how this treatment facilitates painless joint movement without muscle spasm, a more rapid healing of the infective process, and a better prognosis for permanent motion in the joint.—*Charles Lyle Hawk, M.D., Los Angeles, California.*

ALGUNAS CONSIDERACIONES SOBRE EL TRATAMIENTO DE LAS OSTEOMIELITIS AGUDAS (Some Considerations of the Treatment of Acute Osteomyelitis). Etienne Sorrell. *Cirurgía Ortopédica y Traumatología*, V, 3, 1937.

The author calls attention to recent publications on the use of antitoxin and staphylococcus serum in the treatment of grave staphylococcic septicaemia and their effect on the prognosis of the disease. He believes that they offer some hope, but that osteomyelitis, in spite of its likeness to grave staphylococcic septicaemia and septic pyaemia with multiple foci, is so different from them in regard to clinical behavior and prognosis that the same therapy cannot be employed indiscriminately.

He holds that localized osteomyelitic foci produce septicaemic foci and secondary foci against which the organism is almost defenseless, as they do not produce the necessary antibodies.

In speaking about the general treatment, the author points out the failure of vaccine therapy and the scanty success of the bacteriophage method. He is convinced that the use of staphylococcus antitoxin and serum is still in the experimental stage, and he cites the good results which he obtained in four hopeless cases by the use of electrocuprol. However, no one of these therapeutic methods precludes the surgical treatment of the lesion. This, of course, varies according to the type of osteomyelitis to be treated.

Four cases are reported, treated as follows: The first, by incision of the periosteum without bone trepanation; the second, which was a little more serious, by simple bone trepanation; the third, even graver than the preceding ones, by a Hallopeau operation,—a resection of the subperiosteal diaphysis; and the fourth, presenting a septicaemic form with few local signs, by arthrotomy and hip drainage, which relieved the pain without changing the septicaemic condition. He compares the evolution of these cases with the probable results of an expectant treatment and arrives at the conclusion that, except in cases of staphylococcic septicaemia with few localized bone symptoms which justify a delay, speedy surgical intervention is indicated, the technique of which depends on the type of lesion present.—*Alberto Inclán, M.D., Havana, Cuba.*

ACUTE HEMATOGENOUS OSTEOMYELITIS IN CHILDREN. Vernon L. Hart. *Journal of the American Medical Association*, CVIII, 524, 1937.

Due to the many types and various stages of osteomyelitis, there is confusion in regard to the proper treatment in the acute stage. This is a local manifestation of a bacteraemia which is itself usually transient. Its first skeletal manifestation is localized in a single metaphysis of a long bone, or in the juxta-epiphyseal region of other bones. It is not in the medullary cavity or in the cortex. Therefore, surgery should be limited to the metaphysis in this stage.

The author presents the anatomy of the condition in a clear manner and the point is brought out that the rupture of the cortex, as the infection extends, takes place in the paper-thin region of the metaphysis adjacent to the epiphyseal line. The infection rarely travels through the avascular epiphyseal disc, and in bones where the epiphyseal line is extracapsular the joints are rarely involved in the infection, for the periosteum is attached at the epiphyseal line. The usual mode of spread is subperiosteal rather than intramedullary and for this reason the medulla should not be disturbed surgically.

The infection remains localized in the metaphysis for several hours to several days. The diagnosis must be made and the operation done within this time to prevent chronic drainage and sequestration. When there is subperiosteal pus, the disease is no longer acute hematogenous osteomyelitis. The name "acute hematogenous metaphysitis" should be added to the terminology, for it describes the phase when surgery may prevent chronicity.

The diagnosis in this stage is not based on swelling, redness, and oedema, for they are not yet present. Point tenderness over the metaphysis is the most important sign. The joint is clinically normal when examined gently and carefully, although there may be limitation of movements. The chief complaint is incessant pain in the neighborhood of the joint. There is intense toxaemia with high temperature and a rapid pulse. The white blood count is as high as 30,000. Roentgenograms in this stage are always negative.

Treatment is divided into two types, depending on whether or not there is cortical rupture. Adequate attention to dehydration and the general condition is a primary

consideration. When the cortex has not been perforated, a small incision to expose just the metaphysis is made and no pus is seen. The periosteum over the region to be decompressed is then elevated, and drill holes, or a window, one-half by one inch, are made in the thin cortex over the point of tenderness. The cancellous bone is not curetted. A culture of the cancellous bone, or pus if it is seen, should be made. The wound is lightly packed with petrolatum gauze and a plaster cast is applied as in the Orr method. This allows drainage without periosteal separation. When cortical rupture takes place, the local symptoms are definitely changed. Swelling, redness, and oedema are then present, and the tenderness and pain are no longer localized to one point as before. In this critical period the treatment has often been too radical, for these children are not good surgical risks. Their general treatment is extremely important. In this stage there is subperiosteal pus, but, as a rule, the medullary cavity is not yet infected. For this reason, the cortex and medulla should not be opened widely. The soft-tissue abscess should be opened widely, however, and the author suggests widening the perforated area in the cortex of the metaphysis. He makes one drill hole into the medulla of the adjacent diaphysis, so that if pus should be present it can escape. This does no harm and may give valuable information. Dressings of the Orr type and a cast are then applied.

Regardless of the treatment, the clinical picture will not dramatically end following this, for there is still a septicaemia. The part should be watched for signs of spreading infection and during this period the general care must continue as before. Any new foci should be treated in the same manner.

The author suggests that in bones where diaphysectomy can be done without sacrificing the function of the part, as in the case of the fibula, such a procedure is indicated. The diaphysis is removed as far as the periosteum has been stripped by the pus.

It is pointed out that in spite of all this treatment many patients will gradually pass into the chronic stage.—*Newton C. Mead, M.D., Dallas, Texas.*

THE EXAMINATION OF THE CEREBRO-SPINAL FLUID. W. E. Carnegie Dickson. *The Medical Press and Circular Supplement*, Symposium No. 1, p. 18, 1937.

This article presents a discussion of the various methods of gaining information through subarachnoid puncture and of the subsequent examination of the fluid obtained.

The author gives a reasonable explanation of the severe headache that often follows lumbar puncture and shows how it may be prevented. He thinks that the headache is due to constant seepage of cerebrospinal fluid from the spine after the needle has been removed and that this seepage may be prevented by a certain method of inserting the needle.

The dura mater is composed of vertically running parallel strands of thickened fibrous tissue in one sheet and it is tense and tight in a vertical direction. If a spinal-puncture needle is inserted with the sharp cutting edge transversely, it will cut one or more of these vertical thickened strands. Since these strands are constantly tense, the needle wound will gap open and allow cerebrospinal fluid to seep out constantly. However, if this needle is inserted so that the cutting edge is vertical, the opening in the dura will be vertical or parallel to the thickened strands. When the needle is withdrawn, the opening closes immediately, due to the tension of the vertical thickened strands of the dura, and seepage of fluid is prevented.—*Herbert E. Hipps, M.D., Marlin, Texas.*

SCHENKELHALSFISSUR MIT SEKUNDÄRER DYSTROPHIE UND ARTHROSIS DEFORMANS (Fracture of the Neck of the Femur with Secondary Dystrophy and Arthrosis Deformans). Paul Sudeck. *Monatsschrift für Unfallheilkunde und Versicherungsmedizin*, XLIV, 249, May 1937.

Following a relatively mild injury that was considered and treated as a contusion of the hip, a man, twenty-three years of age, developed progressive symptoms of pain, atrophy, and circulatory disturbances of the extremity. This was associated with a flexion and abduction contracture of the hip, with limited, painful motion. Roentgenographic studies over a course of two years revealed a marked spotty atrophy of the

bones about the hip, with a deposition of lime salts to give the appearance of an arthrosis deformans. The neck of the femur was found to have been fractured on the posterior aspect and to have healed with callus overgrowth.

Sudeck postulates that, following a relatively mild incomplete fracture of the neck of the femur, there occurred a secondary distrophy and eventually an arthrosis deformans.—*I. William Nachlas, M.D., Baltimore, Maryland.*

New Amputation Through Femur at the Knee. C. Latimer Callander. *Northwest Medicine*, XXXVI, 49, Feb. 1937.

The author presents a method of low amputation of the thigh through the use of extra long flaps and the severance of the muscles through their tendinous attachments only, a splitting of the tissues along their fascial planes. The weight-bearing end is covered by the patellar fossa of the quadriceps tendon. He reports thirty-nine cases, in most of which the patients were over seventy years of age, with a mortality of only 9 per cent.—*Charles Lyle Hawk, M.D., Los Angeles, California.*

Le tabes polyarthropathique (Tabetic Polyarthropathy). Henri Roger, Paul Vigne, et A.-Maurice Recordier. *La Presse Médicale*, XLV, 118, 1937.

The authors report the case of a female whom they first saw in 1923 at the age of fifty-eight. At that time the patient had suffered over a period of fifteen years from lightning pains, etc. In 1916 an arthropathy of the left hip developed. This patient manifested typical signs of tabes. In 1933 the right hip was involved and the lumbosacral, the thoracic, and the cervical spines later became involved. Both shoulders showed a typical Charcot destruction. Both knees demonstrated osseous changes. The left elbow presented osteophytes and the hands showed evidence of decalcification.

Attention is called to the fact that, although tabes usually is monarticular, it may equally well be polyarticular.—*Henry Milch, M.D., New York, N. Y.*

Arthroses micro-polytraumatiques du coude (Microtraumatic Arthroses of the Elbow). J. Belot et L. Nahan. *La Presse Médicale*, XLV, 135, 1937.

A number of interesting roentgenograms are presented, describing the osteo-arthritic lesions which are found in the elbow joints of employees, following the prolonged use of the pneumatic hammer. While the elbow is most frequently afflicted, the wrist or shoulder may also be involved. The condition develops insidiously as a result of prolonged microtraumata. The patients are usually symptom-free, until some trivial accident attracts the attention of the physician to the involved region. The trauma usually elicits mild pain, which apparently disappears while the patient is at work, and which seemingly is not affected by change of temperature. Flexion is moderately interfered with; extension is seldom completely possible. Supination, however, is limited to a much less degree than the extent of the involvement, as demonstrated by the roentgenograms, would lead one to believe.

While the trauma caused by the use of the pneumatic hammer cannot be denied, the fact is that the condition develops in only a small percentage of laborers,—in not over 2 per cent. This raises the question as to whether there may not be an underlying vasomotor imbalance, which may be the fundamental basis upon which the repeated traumata make their appearance.—*Henry Milch, M.D., New York, N. Y.*

L'ostéo-arthrite sèche trapézo-métacarpienne (Dry Osteo-Arthritis of the Trapeziometacarpal Joint). Jacques Forestier. *La Presse Médicale*, XLV, 315, 1937.

Forestier calls attention to the fact that the carpometacarpal joint of the thumb is frequently the site of degenerative arthrosis. The condition is more frequently found in women than in men, appears to be most commonly associated with the menopausal period, and makes its appearance between fifty and seventy years of age.

Fifty-seven cases have been seen by the author among 4,000 cases of arthritides of varying etiology. The condition is characterized by diffuse pain felt along the radial border of the hand. It is apparently made worse by movements or efforts at prehension and is not affected by change of weather. Clinically, the onset of the condition is marked by a definite increase in the size of the joint and crepitation, without limitation of motion. Later, limitation of motion, especially of abduction of the thumb, appears, and finally there is an outward and forward dislocation of the base of the proximal phalanx, which explains the prominence noted at the base of the thumb. Pathologically, this condition would seem to be due to a degenerative form of arthritis, and is to be grouped in the class of osteo-arthroses. Roentgenographically, the condition is characterized by narrowing of the joint interspace, the development of osteophytes on the trapezium, and, ultimately, outward dislocation on the base of the phalanx.

The condition must be differentiated from the stenosing tenovaginitis or injuries to the carpal bones. In the majority of instances the onset is insidious and the course is characterized by pain over a period of from six to ten years. Apart from the aesthetic appearance of the thumb, the prognosis is not unfavorable. The pain usually disappears within several years. Treatment should consist of the general treatment of the degenerative arthroses,—iodine, sulphur, thyroid and ovarian extracts. Functional rest, actinotherapy, ionization, and diathermy have proved of some value locally.

In the very painful form the author has performed drilling, both of the trapezium and of the base of the phalanx, with some improvement.—*Henry Milch, M.D., New York, N. Y.*

L'ARTHROGRAPHIE DANS LA LUXATION CONGÉNITALE DE LA HANCHE (Arthrography in Congenital Dislocation of the Hip). Jacques Leveuf et Pierre Bertrand. *La Presse Médicale*, XLV, 437, 1937.

The authors report fifteen cases of congenital dislocation of the hip in which the arthrographic method was used for the purpose of determining the validity of closed reduction or the necessity for open operation. The technique used by the authors consists in the injection of from one to ten cubic centimeters of a 35-per-cent. solution of diagnorénol, or a 30-per-cent. solution of ténébryl. Because of the attendant pain, the authors advise the use of general anaesthesia in children or local anaesthesia (one to two cubic centimeters of novocain) in adults. The method is quite in line with that proposed by Bircher, Böhm, Marziani, Galland, and others. In the dislocated hips a cotyloid chamber and a cephalic chamber, separated by an isthmus, can be made out. The width of the isthmus varies, depending on the presence of adhesions, the size of the round ligament, shelf formation, etc. As in the hands of other workers, this method has proved of great value in establishing the true nature of the dislocation. The authors do not mention any ill results following the use of the interarticular medication.—*Henry Milch, M.D., New York, N. Y.*

SUR LE TRAITEMENT PAR LA SPLÉNECTOMIE DU SYNDROME DIT DE CHAUFFARD-STILL (Splenectomy in the Treatment of Chauffard-Still Syndrome). M. Loeper, André Lemaire, et Jean Patel. *La Presse Médicale*, XLV, 625, 1937.

The authors report a case of Chauffard-Still disease occurring in an adult, aged twenty-eight. There was a bilateral symmetrical deforming arthritis of the hand, with evidence of arthritic involvement of the wrists, knees, etc. Examination also showed marked splenomegaly, no leukopenia, and an enlargement of the regional lymph glands. Following splenectomy, the pains and functional impairment of the joints disappeared. Swelling became less, and the temperature fell to normal. The anaemia improved. Two weeks after operation a phlebitis of the left leg developed, which gradually subsided within three weeks. The patient died subsequently of a so-called grippal bronchial pneumonia. A discussion of the rôle of splenectomy in arthritis in general is given.—*Henry Milch, M.D., New York, N. Y.*

MYOSITIS OSSIFICANS PROGRESSIVA. E. A. Cockayne. *Proceedings of the Royal Society of Medicine*, XXX, 162, 1936.

The author reports the case of a female, aged twenty-three, with several congenital anomalies of the hands and feet, including shortened metacarpals and metatarsals, and some lengthened phalanges. The family history was negative. A year previous to examination she had had pain and swelling in both calves with no apparent cause. The muscles felt hard and tight, and she could not walk. The condition grew progressively worse and four months later she had had a hard, tender swelling, about two and one-half inches long, on the inner side of each gastrocnemius. A month later, a firm, tender, painful swelling had appeared on the lower part of the left soleus muscle; this had been followed in a few days by a larger swelling on the right soleus. Roentgenograms showed no evidence of bone formation in either gastrocnemius.

This case is one of myositis ossificans progressiva, diagnosed before actual ossification had begun. The etiology is unknown, but the presence of malformations of the metacarpals and metatarsals is established as part of the disease in most instances. The relationship between the two is obscure. The unusual feature of this case is the late onset of symptoms; the majority of cases appear in early childhood.

Treatment is speculative. Parathormone injections, to attempt the mobilization of calcium salts when detectable by the roentgenogram, are suggested, and, in addition, the simultaneous administration of acid sodium phosphate to keep up the blood phosphorus, since some degree of acidosis has seemed to help in the treatment of calcinosis.—*B. M. Halbstein, M.D., Iowa City, Iowa.*

OSTEOCHONDROSIS-OSTEOCHONDRITIS ISCHIO-PUBICA. A. A. Zeitlin. *Radiology*, XXVII, 722, 1936.

Through extensive investigations, the author has been able to "distinguish a special group of lesions in the osteochondral part of the epiphysis of growing bone, which are at present united under the name of epiphysitis or juvenile osteochondropathy". To the uncommon localization of this process belong lesions of the ischiopubic synchondrosis. He divides the cases into two groups:

1. Those with changes based on impairment of the normal process of ossification. This type he proposes to call "osteochondrosis ischio pubica".
2. Those characterized by an inflammatory reaction, and known as "osteochondritis ischio pubica".

Ossification of the ischiopubic cartilage occurs at about eight years of age.

Osteochondrosis shows in the roentgenogram a round or oval focus of rarefaction with distinct contours. Characteristic is the projection of the bony cartilaginous mass in the form of a triangular promontory in the lumen of the foramen obturatum. Strips of normal bone are left on the medial and lateral sides.

In cases of osteochondritis the process of decalcification and dystrophy is not limited to the synchondrosis, but is transferred to the adjoining parts of the os pubis and the os ischii, forming one continuous focus or appearing as a number of separate spots. The process is of longer duration, and in far advanced cases there may be considerable deformation.

The author discusses the differential diagnosis and reports some cases of both types. No biopsies are reported to verify the diagnosis.

The prognosis in both diseases is favorable and, while it is better in osteochondrosis, osteochondritis does not usually produce anything more severe than a deformity of the pubis.—*T. A. Angland, M.D., Iowa City, Iowa.*

ZERRUNGSSCHÄDEN DER KNIESCHEIBENSEHNE (Injuries to the Patellar Tendon Due to Strain). Alfred Saxl. *Zeitschrift für Orthopädie*, LXV, 129, 1936.

Repeated overstretching of the patellar tendon, due to excessive and forceful flexion

movements of the knee, is apt to produce a traumatic periostitis at the sites of attachment of the patellar tendon on the lower pole of the patella and the tibial tuberosity. The condition is characterized by pain and localized tenderness with or without swelling over the sites mentioned. Roentgenographic findings are completely negative. This condition must not be confused with Osgood-Schlatter disease, in which the age and positive roentgenographic findings are of definite aid in diagnosis. The condition is treated by immobilization of the knee in an elastic bandage with an attempt to push the patella downward, so as to relax the patellar ligament.

The author has observed this condition in five adults.—*Harold Unger, M.D., Iowa City, Iowa.*

ÜBER DIE HINTERE ANSCHLAGSPERRE DES OBEREN SPRUNGGELENKS (Posterior Bone Block of the Ankle Joint). W. Dega. *Zeitschrift für Orthopädie*, LXV, 236, 1936.

The author presents an analysis of twenty-two posterior bone-block operations.

Camera's interarticular technique was used in eleven cases. In this method a tibial graft is driven from above into the posterosuperior portion of the astragalus. The free end of the graft is only one centimeter in length and reaches the posterior inferior border of the tibia when the foot is at a right angle with the leg. The immediate functional results after this operation were good, but, from several months to several years later, the patients began to complain of pain, due to the arthritic changes in the lower end of the tibia and the free end of the graft. In several instances there followed an arthrodesis of the ankle; while in others the graft became detached from the astragalus and united with the lower end of the tibia. In the latter instances the results were not necessarily bad. Of seven follow-up examinations several years later, the results were excellent in only two, fair in two, and poor in three.

Gill's method was used in one case. The result is uncertain.

In the remaining ten cases the author used a modified Nové-Josserand extra-articular method, which is similar to Campbell's technique. Only one incision is used, which arches from above and behind to below and around the external malleolus. A triple arthrodesis is performed, but the posterior subastragalar half of the superior portion of the calcaneum is not resected. This portion is partially chiseled away from above and anterior to below and posterior. It is then pried posteriorly until it forms a right angle with the calcaneum, and is allowed to attach itself to the lower posterior surface of the tibia. Eight follow-up examinations, from several years to ten years after operation, revealed good functional results, with no pain, in all cases.—*Harold Unger, M.D., Iowa City, Iowa.*

TECHNIK UND RESULTATE MEINER PSEUDARTHROSENOPERATION (Technique and Results of My Operation for Pseudarthrosis). Hermann Matti. *Zentralblatt für Chirurgie*, LXIII, 1442, 1936.

In 1929 the author described a new operative technique for pseudarthrosis. He now reviews the results obtained in fifty-five cases. Complete bony consolidation was obtained in fifty-two cases, or 94.5 per cent.

The following technique was used: Lateral incisions are made in the femur, in the humerus, and in the forearm, and an anterior oval incision in the tibia. In the latter, the incision goes immediately to the bone, so that periosteum and skin are not separated to obtain better nutrition. From the cleft, the anterior wall of both fragments is chiseled out for from six to eight centimeters. Excision of the fibrous-tissue disc between both fragments follows, except for a small bridge (two centimeters) which prevents lateral dislocation. The next step is a careful removal of the marrow and spongiosa by curettage. Experiments on animals show a marked stimulation and increase of endosteal-callus formation when the marrow and spongiosa are taken out. The whole excavation is then filled with small pieces of spongy bone. These are obtained by chiseling the greater

trochanter and removing the spongy material which can be found there in great amounts. In cases of pseudarthrosis of the tibia the material can be taken out from the tibial condyles. The spongy-bone pieces used to fill the hole are about one-half of a cubic centimeter in size and may be square or round in shape. If there are some spaces between them, they can be filled with bone chips from the previously removed compact bone. The wound is closed in the usual manner, without drainage. If hematoma occurs, removal by aspiration with a syringe is indicated. A plaster cast is applied, or extension is made with a wire or pin. The important advantage of the method over a bone graft is that it can be used also in cases of infection when one solid graft probably would fail to take. The average time required for complete bony healing to take place in adults was from eight to ten weeks in the tibia and from ten to twelve weeks in the femur. The author does not allow the patient to walk in the plaster cast until the roentgenogram shows at least a small calcified bridge between the fragments.—*Joseph Wolf, M.D., Iowa City, Iowa.*

ECHINOCOCCUS DES ILEOSAKRALGELENKES (Echinococcus of the Sacro-Iliac Joint). Kagalnitzky. *Zentralblatt für Chirurgie,* LXIII, 1705, 1936.

The author describes an echinococcus cyst in the sacro-iliac joint, a localization until now not recorded in the literature. The patient was a laborer, thirty-two years old. Five years ago he had noticed a slowly growing tumor over the left sacro-iliac joint, which had rapidly increased in size during the past year. At operation, a tumor the size of a man's fist was found, containing many living and dead echinococcus cysts. Complete healing took place.—*Joseph Wolf, M.D., Iowa City, Iowa.*

WIE ENTSTEHEN PSEUDARTHROSEN UND ANDERE MISSERFOLGE NACH NAGELUNG MEDIALER SCHENKELHALSBRÜCHE (How Do Pseudarthroses and Other Bad Results Occur after Nailing of Medial Fractures of the Femoral Neck)? Fritz Felsenreich. *Zentralblatt für Chirurgie,* LXIII, 2843, 1936.

Most observers believe that shearing stresses play the greatest rôle in the production of pseudarthroses after nailing in medial femoral-neck fractures. The nail, centrally placed, but lying in the cranial quadrant of the femoral head, is forced upward under shearing stresses and finally works its way through and above the head. This results in a sinking and a varus deformity of the femoral head, the outcome of which is pseudarthrosis.

On more careful observation, however, one discovers that there is a more important factor in the production of pseudarthrosis than that attributed to shearing force. Many investigators have frequently observed a progressive external rotation of the femoral shaft, beginning ten to twenty days postoperatively, usually as a result of motion. Concomitant with this external rotation of the shaft, there is also an independent clockwise rotation of the femoral head about a transverse frontal axis. These processes are apt to occur most frequently when the nail lies in the anterior segment of the femoral head and less frequently when it is placed in the lower and posterior segments of the head. This rotation of the head inevitably results in a sinking and a varus deformity of the head and thus in a pseudarthrosis.

In the four cases observed by the author, the latter factor was responsible for the non-union. In Nyström's series of twenty-nine cases of pseudarthrosis practically the same percentage was also attributed to this factor.—*Harold Unger, M.D., Iowa City, Iowa.*

ZUR OPERATIVEN BEHANDLUNG DER HABITUELLEN LUXATION DES SCHULTERGELENKS (The Operative Treatment of Habitual Dislocation of the Shoulder). Hermann Matti. *Zentralblatt für Chirurgie,* LXIII, 3011, 1936.

The author makes a pectorodeltoid incision. The subscapularis tendon is freed and

divided close to its insertion on the lesser tubercle of the humerus. The anterior relaxed portion of the capsule is picked up as a fold and sutured to the remaining attached stump of the subscapularis tendon. By means of a chisel, a periosteocortical flap is reflected from the greater tuberosity just external to the intertubercular sulcus. The arm is rotated internally, and the subscapularis tendon is pulled laterally and anchored with silk under this osseous flap. A nail may be used for further fixation of the flap and tendon against the humerus. The arm is immobilized in internal rotation for three weeks.

This operation was carried out successfully on twelve patients; however, not enough time has elapsed for a permanent end-result evaluation. In all the patients a partial limitation of external rotation developed after this operation. This the author regards as a safeguard against relapse.

This operative procedure is a slight modification of the de Quervain method, in which the transplanted subscapularis tendon is simply sutured subperiosteally to the greater tuberosity of the humerus.—*Harold Unger, M.D., Iowa City, Iowa.*

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SURGICAL BONE GRAFTING WITH "OS PURUM", "OS NOVUM", AND "BOILED BONE" *

BY SVANTE ORELL, M.D., STOCKHOLM, SWEDEN

Instead of the commonly used fresh autoplastic bone graft, I have employed three other forms of grafts which I have called "os purum", "os novum", and "boiled bone". Each of these has its special range of use, its advantages, and its disadvantages. My use of these materials in the clinic gradually evolved during several years of experimental work on this subject. The results of these studies may be found in my previous publications. (See Bibliography.) I wish here briefly to describe these materials and to summarize the end results which I have obtained with their use.

Os purum is bone which has been freed of fat, connective tissue, and proteins by means of a lengthy physicochemical process, but it is not freed entirely of all the collagenous matrix. Bone obtained from a slaughter house, or occasionally from amputation specimens, is first mechanically freed of the surrounding soft tissues. The bone ends are then sawed off. The protein (blood protein, etc.) is extracted by soaking the bone in salt solution; the connective tissue on the bone surface and in the haversian canals is removed by soaking in warm potassium hydroxide; and the fat is extracted by soaking in acetone. The bone canals are carefully irrigated between the various processes. By means of this cleansing procedure, the bone canals are emptied and are thus free to admit the tissue fluids and the tissue cells growing in after implantation. Various shapes of os purum are shown in Figure 1.

Os novum, in contradistinction to os purum which is composed of the calcium framework of dead bone, is immature living bone tissue with great proliferative power. It is produced by implanting a long, narrow os-purum splint of suitable shape subperiosteally over the anteromedial

* Read at the Annual Meeting of the American Orthopaedic Association, Lincoln, Nebraska, June 3, 1937.

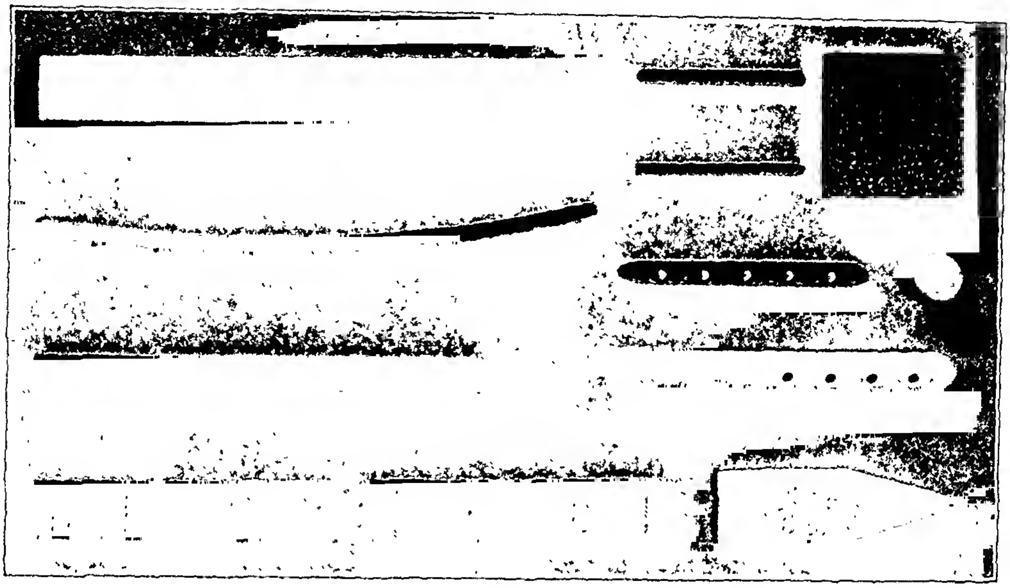


Fig. 1

Various forms of os purum compactum and os purum spongiosum. (*Courtesy of Aktiebolaget Pharmacia.*)

surface of the tibia. This procedure is shown in Figures 2 and 3. When the material is excised from one to two months later, a profuse growth of

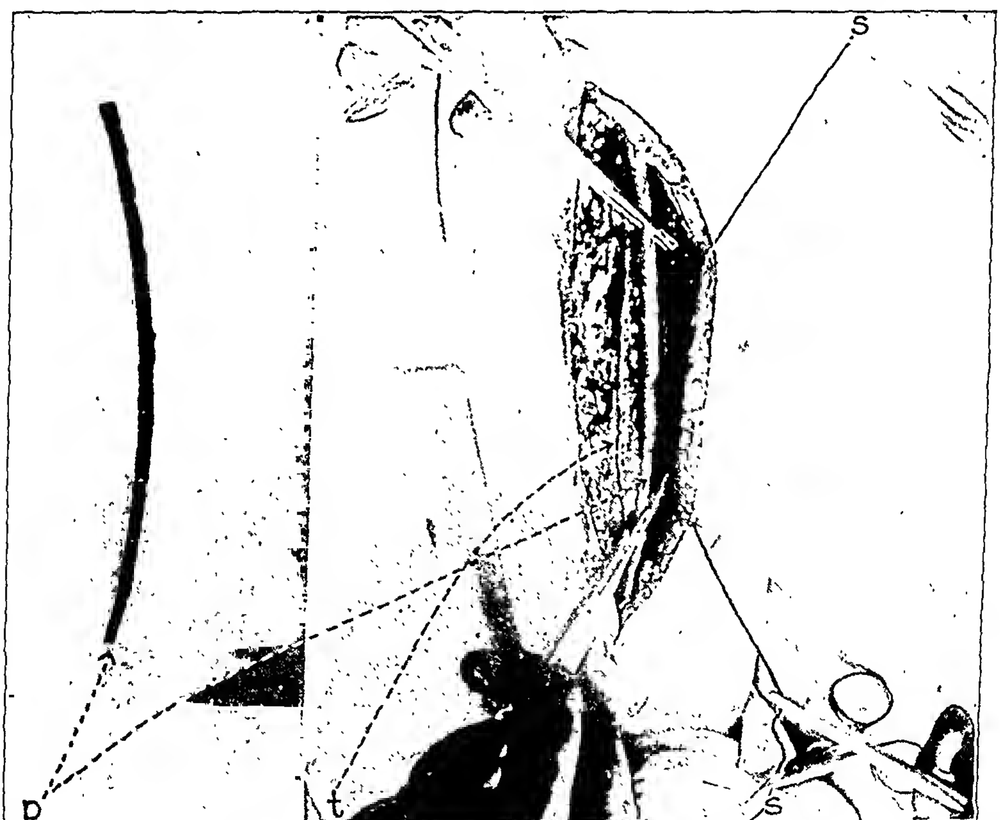


Fig. 2

Subperiosteal implantation of os purum over the anteromedial surface of the tibia. The sutures in the medial periosteal flap are indicated by *s*, the tibia by *t*, and the os purum by *p*. (*Courtesy of Acta Societatis Medicorum Suecanae and of Vromant & Co.*)

CLINICAL EXPERIENCES WITH OS PURUM

When using implants in the skeleton—that is, in places containing skeletal connective tissue—os purum may be employed. This connective tissue proliferates and quickly forms a large amount of new bone in the clefts between the implant, the fixed bone in the bed, and the periosteum, and grows into the open haversian canals of the os purum. Complete resorption of the os purum and its replacement by new bone proceed slowly, however, and may take two or three years for completion, but from clinical experience I have learned that the mechanical support furnished by the graft during the period of reconstruction is sufficient to prevent collapse until the new bone is developed and is able to take over the supporting function.

I have used os purum for implantation in about fifty cases in which bone has been resected for various reasons (most often for tuberculosis) in order to fill the defects, to lessen the risk of deformities, and to fix skeletal parts to one another. In cases in which the skin was intact and the disease process was in a quiescent stage, these implants underwent reconstruction without complications. When abscesses or fistulae were present, the implant was often extruded.

A brief summary of the cases in which os purum has been used, together with roentgenograms of representative cases, follows.

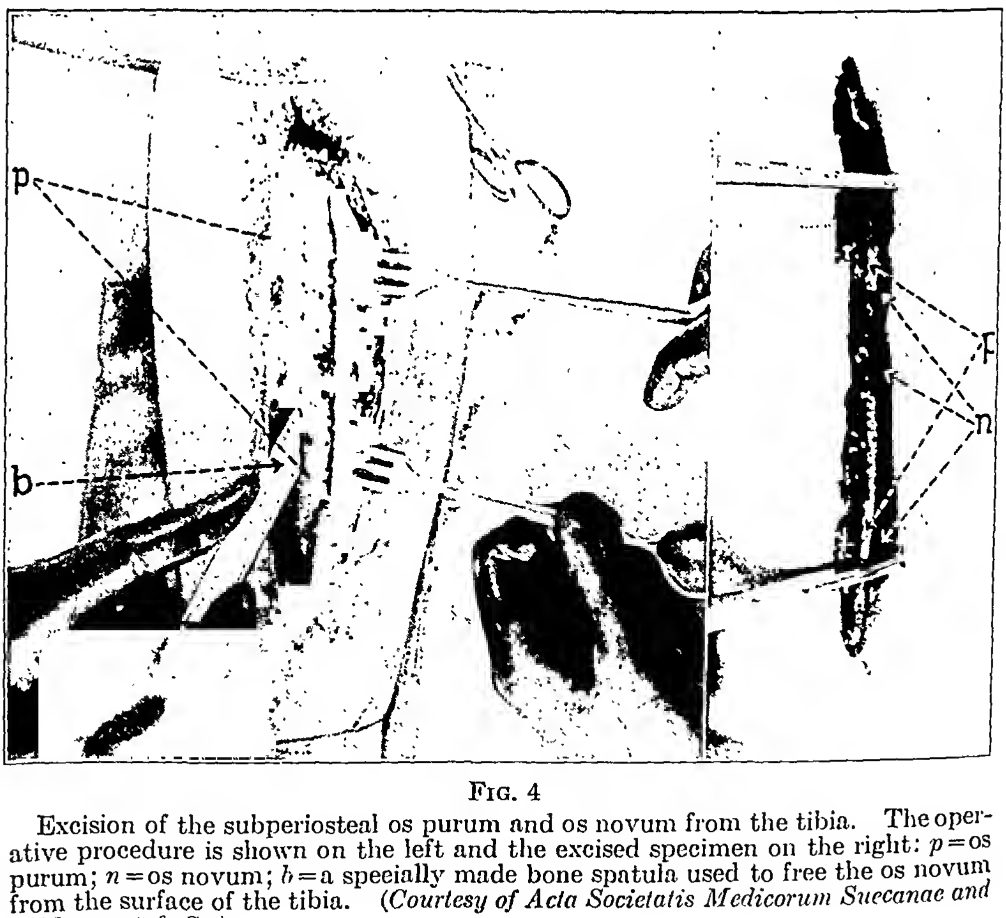


FIG. 4

Excision of the subperiosteal os purum and os novum from the tibia. The operative procedure is shown on the left and the excised specimen on the right: p = os purum; n = os novum; b = a specially made bone spatula used to free the os novum from the surface of the tibia. *(Courtesy of Acta Societatis Medicorum Suecanae and of Vromant & Co.)*

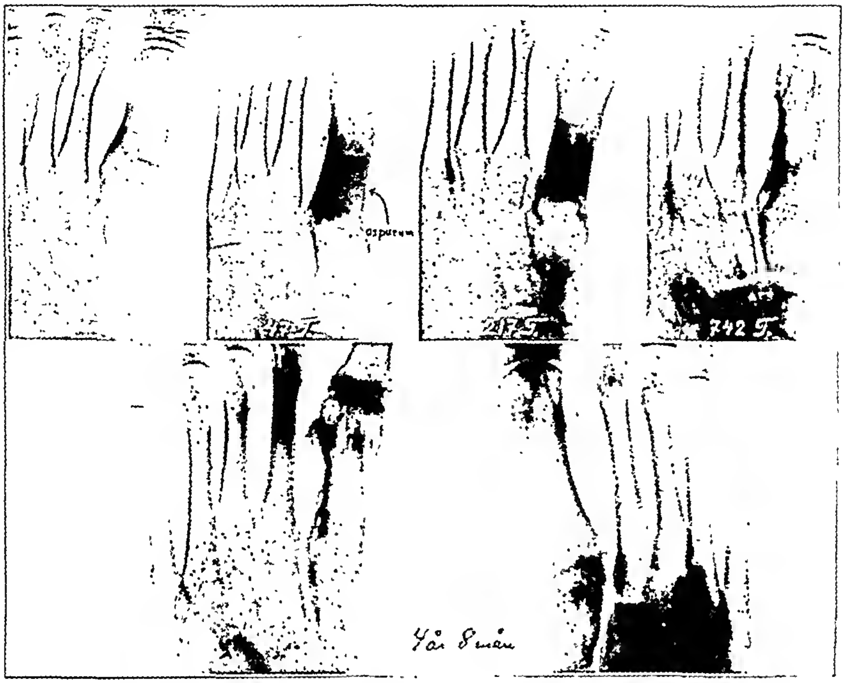


FIG. 5

Tuberculous osteitis in the first metatarsal bone of a boy eleven years old. On June 29, 1931, the lesion was scraped out and the bone was resected. The resected bone was replaced by os purum of similar shape, with primary healing. Eleven weeks after the operation the plaster cast was removed, and five months after the operation the patient was up and walking with shoes on. Good functional and anatomical results were obtained. The roentgenograms show the condition before operation, 47, 217, and 742 days after operation, and four years and eight months after operation. (*Courtesy of Acta Societatis Medicorum Suecanae.*)

Os purum was used in four cases of extra-articular tuberculous osteitis in the bones of the hands or the feet. Primary healing occurred in each case. The patient was usually able to discard his cast and, in the cases involving the feet, to get up two to three months after operation. The grafts were completely reconstructed in from one and one-half to two years after operation. Good anatomical and functional results were obtained in all cases. (See Figure 5.)

Of eight cases of tuberculous osteitis of the small bones of the hands and the feet with involvement of the neighboring joints, good results after grafting were obtained in all but two cases in which fistulae were present before operation. In one case, also, there was an exacerbation of pulmonary tuberculosis, and death occurred in another from pulmonary embolism. The roentgenograms in the latter cases showed marked resorption of the os purum without visible signs of new bone formation.

I have used os purum in three cases of para-articular lesions about the knee joint,—one case with a bone cyst, one with osteitis fibrosa, and one with tuberculous osteitis. There was primary healing in all. The reconstruction was good from one and one-half to two years later, and the

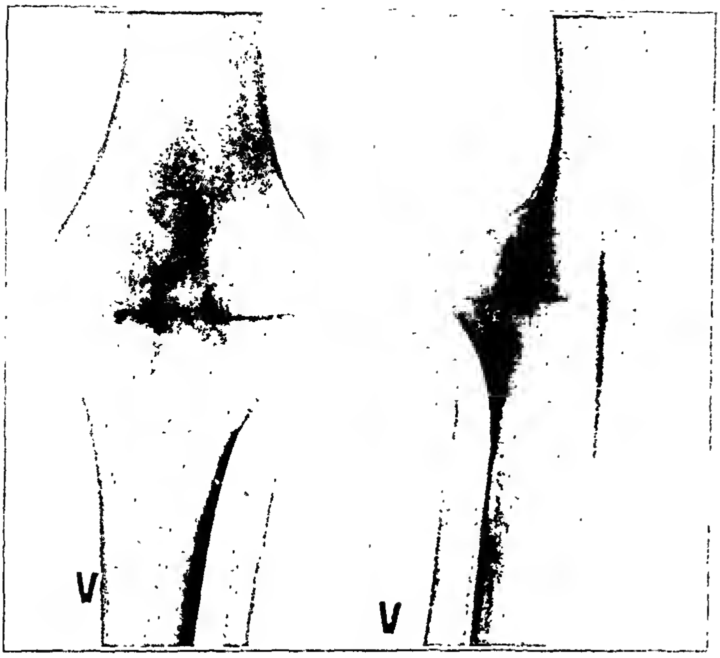


Fig. 6

Posterior and lateral roentgenograms of the left knee joint of a woman, twenty-one years old, 193 days after resection of the knee joint for tuberculosis and implantation of a wedge of os purum compactum. Primary healing occurred. The patient was up and about with a plaster cast two months after operation. The cast was discarded six months after operation.

Similar operations have been performed in eighteen cases in adults, all with good results. (*Courtesy of Acta Chirurgica Scandinavica.*)

anatomical and functional results were all good.

In two other cases of para-articular tuberculous lesions in which os purum was used—one in the acetabulum and femoral head, the other in the os pubis—good results were obtained.

In thirty-one cases of tuberculosis of the joints of the foot, the knee, or the shoulder, os purum was used as a graft to fill up bone defects after resection or to establish osteosynthesis. (See Figure 6.) Primary healing occurred in all the cases. It is interesting to note that when pieces of cancellous os purum were implanted to replace the bone removed at foot-joint resections, they were well able to withstand the great pressure to which they were subjected and underwent complete reconstruction without roentgenographic evidence of collapse. (See Figures 7-A and 7-B.) In only one case of tuberculosis of the foot joint, in which fistulae were present before operation, reconstruction was delayed and the healing was not primary.

Finally, os purum was used in an osteoplastic cuneiform osteotomy of the lower leg, and a good result was obtained. The danger of pseudarthrosis in such cases is great, however, and may necessitate the use of os novum.

CLINICAL EXPERIENCES WITH OS NOVUM

In instances in which extraskeletal connective tissue separates two bones which are to be joined through transplantation, living-bone implants such as os novum, not dead os purum, should be employed. Examples of this use are: osteosynthesis of the spinous processes in tuberculosis of the vertebrae, arthrodesis in iliosacral tuberculosis or tuberculosis of other joints, osteosynthesis in pseudarthrosis, arthroplasty, etc.

I have used os novum for the osteosynthesis of the spinous processes of the vertebrae in about sixty cases, with good results to date. (See

Figure 8.) The transformation of the new bone formed after the implantation of os novum proceeds more uniformly than is the case after the transplantation of fresh mature bone, probably because calcium-containing necrotic bone prevents the formation of new bone. The newly formed splint is firm throughout. Weak areas or defects do not appear as readily as after the transplantation of mature fresh bone, and consequently fractures do not occur. No real fracture of os novum has been observed in any of the cases operated upon to date.

Os novum has been employed for arthrodesis in four cases of tuberculosis of the sacro-iliac joint, with good results in all cases. From three to four months after operation, the patients were up and about and without complaints.

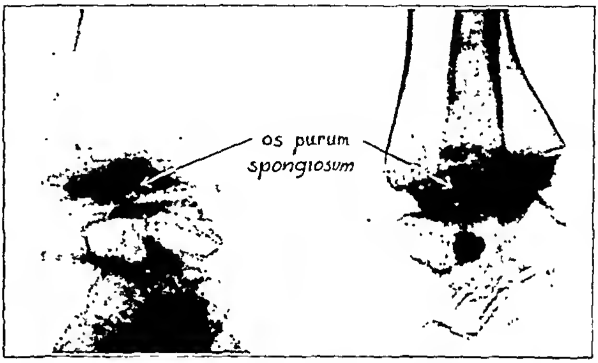


Fig. 7-A

Fig. 7-B

Tuberculosis of the ankle joint of a male, seventeen years of age. Posterior and lateral roentgenograms of the right foot fifty-seven days (Fig. 7-A) and 643 days (Fig. 7-B) after resection of the ankle joint and replacement of the resected bone by a disc of os purum spongiosum. Primary healing took place. The patient was up and walking with a plaster cast three months after operation and has since worked for several years in a lumber yard.

Similar operations have been performed in eight other cases of tuberculosis of the ankle joint, with uniformly good results. (*Courtesy of Nordisk Medicinsk Tidskrift.*)

I have used os novum for osteosynthesis in eleven cases of pseudarthrosis with good results. (See Figure 9.) In these operations I have not, as a rule, excised the soft tissues of the pseudarthrosis. Os novum has been laid down in longitudinal strips like periosteal callus around the pseudarthrosis. The external fixation of the pseudarthrosis with casts or splints during the healing period is very important, and the duration of the fixation varies considerably according to the type of case. I hope to be able to report on this aspect in more detail at a later date.

I have also employed os novum in two cases for so-called semiarthroplasty—that is, in arthroplasty of one joint surface when the opposite joint surface is healthy—but these cases need a longer follow-up period before the results may be fully evaluated.

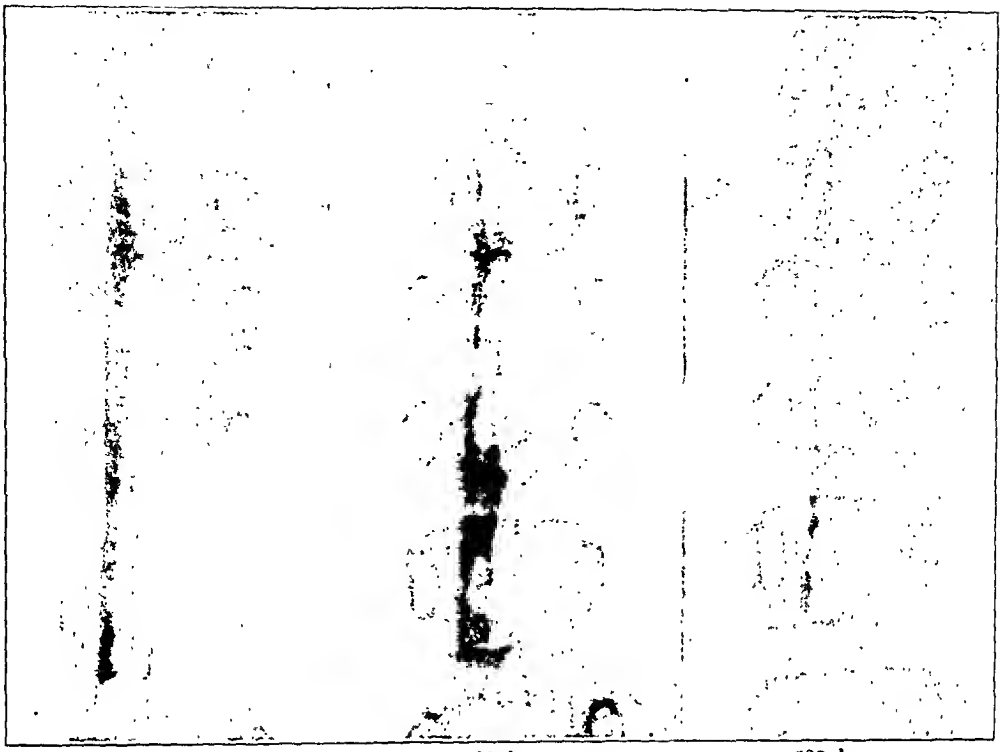


Fig. 8

Tuberculous spondylitis in a boy of twelve years. A subperiosteal implantation of os purum over the tibia was done on September 13, 1932, followed by an osteosynthesis on November 11, 1932. Os purum and os novum were transplanted from the tibia to the split spinous processes of the vertebrae. The roentgenograms show the vertebrae 81, 300, and 629 days after operation. Primary healing occurred. The patient was able to walk with a corset the fourth month after operation. Good functional and anatomical results were obtained. The os purum, rich in calcium, is resorbed, while the os novum gradually acquires the same density and structure as the adjacent vertebrae. *(Courtesy of Acta Societatis Medicorum Suecanae and of Vromant & Co.)*

CLINICAL EXPERIENCES WITH BOILED BONE

I have also used boiled bone which, though not ideal, often has the proper shape and structure for replantation. I have used it when the bone is in a pathological condition—in chronic osteomyelitis, in bone tumors, etc.—when it has not been so easy to use os purum or os novum. I have then resected the diseased bone, boiled it in a physiological salt solution to kill the bacteria or tumor cells, cleared it of the diseased tissue masses, and replanted it to give mechanical support until new bone had been developed, at the same time using it as a stimulant to the living connective tissue in the bed.

I have treated four cases of chronic osteomyelitis with resection and replantation of boiled bone. Satisfactory results were obtained in all four cases. The healing usually took from six months to one year, with sequestration of a part of the replanted bone, but, in spite of this, the patients were up and about in from three to six months after the operation. There were no recurrences. One of these cases is shown in Figure 10.

Fig. 9

Lateral roentgenograms of the right forearm before operation and 51, 220, and 414 days after operation for pseudarthrosis in the right ulna, following a compound fracture of the forearm sustained during an accident in May 1933. The patient was a fifty-year-old farmhand. On January 7, 1935, the interposed tissue was excised and the space between the ends of the bones was filled up as completely as possible with os novum. Several os-purum splints were implanted subperiosteally. Primary healing occurred despite thin, friable, and scarred skin. There was good consolidation seven weeks after operation. The patient has been working daily as a laborer since January 1936.

Os novum has been transplanted in the same manner in ten other cases of pseudarthrosis, with good results. *(Courtesy of Acta Societatis Medicorum Suecanae.)*

Fig. 10

Chronic osteomyelitis in the left femur of twelve years' duration in a woman, twenty-five years of age. On September 12, 1935, an osteotomy through the neck of the femur was performed. The diseased superior portion of the femur was freed and brought out through the wound, boiled for ten minutes in physiological salt solution, cleaned of necrotic bone, and replaced. Primary healing occurred. The patient was in bed for three months, then up and about with a plaster cast. Abscesses appeared in the soft parts twice after operation. She has since been well. The roentgenograms show the condition before operation and 24 and 240 days after operation. *(Courtesy of Acta Societatis Medicorum Suecanae.)*

This method has also been used in one case of malignant periosteal osteogenic sarcoma in the upper end of the humerus. (See Figure 12.) This case may be sufficiently interesting to justify a more detailed report.

The patient, a boy, sixteen years of age, had had symptoms since April 20, 1935. On August 8, 1935, a subperiosteal resection of two-thirds of the humerus and exarticulation of the shoulder joint were performed. The resected bone was boiled for from fifteen to twenty minutes; the tumor masses were scraped away; and multiple perforations were made in the bone to facilitate its resorption. The bone was then replanted.

Two months after the operation consolidation had taken place and the patient was up and about. Three months after the operation the cast was discarded. On December 29, in the fourth month after the operation, a spontaneous fracture was discovered in the replanted portion of the humerus. The patient had a good range of movement in the shoulder joint. There was no local recurrence, but a metastasis developed in the base of the right lung in October 1936. The patient died on November 26, 1936, fifteen and one-half months after the operation.

The pathological diagnosis of the tissue removed at operation was "an unusual form of telangiectatic chondro- and osteoplastic sarcoma". No recurrence in the humerus or in the soft parts of the upper arm was found at post-mortem examination.

This case is interesting in that there was no local recurrence during the fifteen and one-half months during which the patient lived after operation. This may be related to the fact that this was an unusual type of sarcoma. It is unfortunate that the pulmonary metastasis occurred, and it is possible, of course, that there would have been no metastasis if the patient had been operated upon earlier. Something has been gained, however, if local tumor necrosis or recurrence may be avoided in this way.

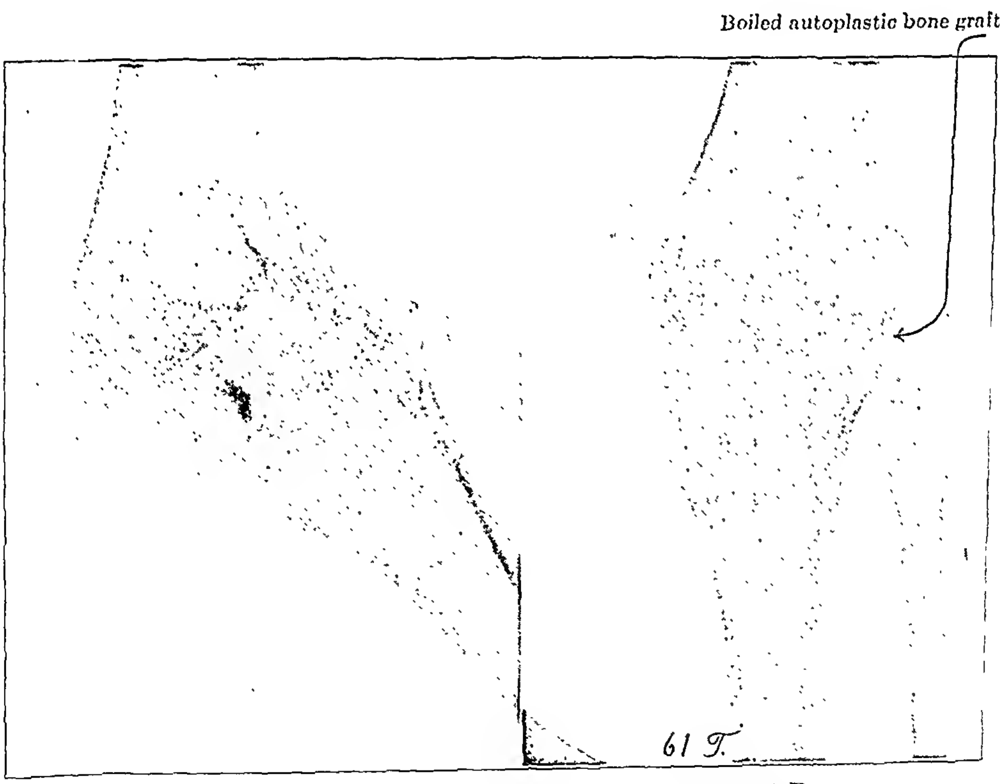


FIG. 11-A FIG. 11-B

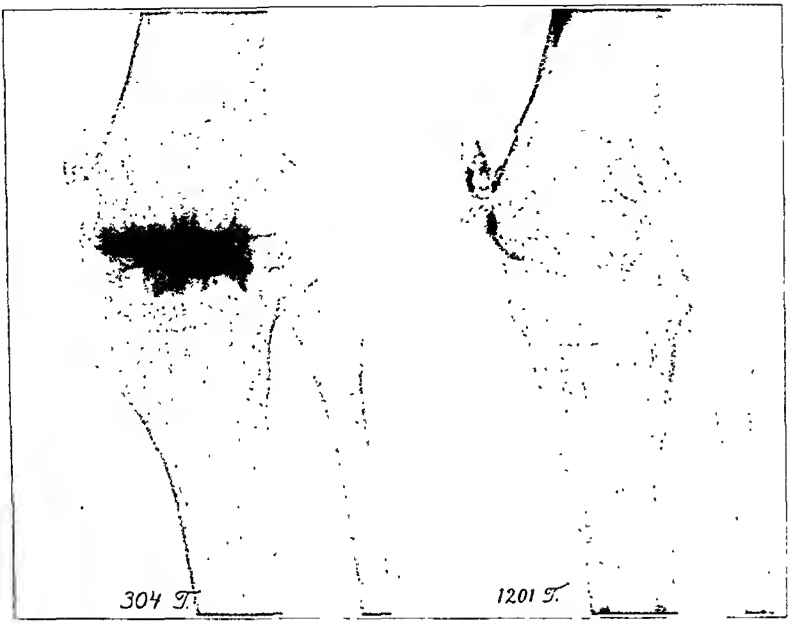


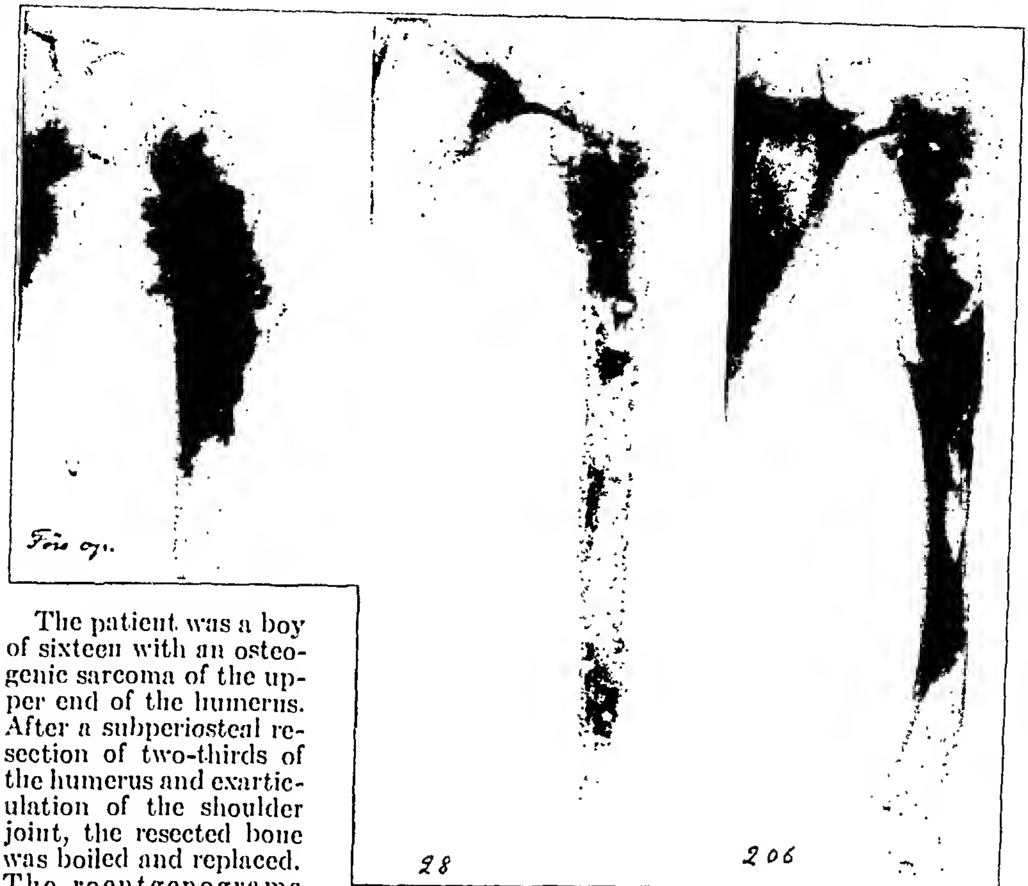
Fig. 11-C Fig. 11-D

Healed tuberculosis of the knee joint with ankylosis in pronounced flexion in a twenty-year-old woman. On May 9, 1930, an "osteoplastic cuneiform osteotomy" was performed. The bone wedge, which during the operation was accidentally touched with a non-sterile object, was boiled for ten minutes in physiological salt solution and replanted, after having been rotated 180 degrees. Primary healing occurred. The patient was up and about wearing a plaster cast nine weeks after operation. Good anatomical and functional results were obtained. The roentgenograms showed increased density and decreased distinctness in structural detail in the bone wedge until about 300 days after the operation. The density then began to decrease gradually, while the bone structure became increasingly evident. About 1000 days after operation, the bone fragment had been entirely replaced by new bone. The patient has been under observation for seven years since the operation. The roentgenograms show the condition before operation and 61, 304, and 1201 days after operation. (*Courtesy of Acta Chirurgica Scandinavica.*)

DISCUSSION

The study of bone-grafting teaches us that the bone should be considered as a tissue, the survival of which, like other living tissues, is dependent upon good nutrition. Every effort should be made to favor the nutrition of the soft tissues about the surface of the fixed bone in the operative field. The periosteum should not be separated from the soft parts lying outside, and the connective tissue in the haversian canals should not be injured through damage to the nutrient vessels. The instruments should be as small as possible and produce the least possible trauma. Experience has taught that the best method of exposing the bone is to loosen the periosteum from it. Nothing is gained by traumatizing the tissues lying external to the periosteum.

The use of these grafts, like that of fresh autoplastic material, requires a strictly aseptic procedure. The skin should be cleaned and washed with alcohol every day for at least three or four days before operation. After



The patient was a boy of sixteen with an osteogenic sarcoma of the upper end of the humerus. After a subperiosteal resection of two-thirds of the humerus and exarticulation of the shoulder joint, the resected bone was boiled and replaced. The roentgenograms show the upper arm before operation and 28 and 206 days after operation.

FIG. 12

(Courtesy of Acta Societatis Medicorum Suecanae.)

operation, the affected parts should be fixed in a plaster cast. A window should be cut over the wound so that it is accessible to the influence of air and light. As a rule, fixation for two or three months is necessary.

The surgical production of os novum shows that the bone-forming cells of the skeletal connective tissue grow most quickly and abundantly into the tissue-free clefts between the periosteum, graft, and bone after preliminary hematoma formation (blood, fibrin, tissue fluids). However, it is not desirable to have the hematoma formation so excessive that the newly formed skeletal connective-tissue cells are unable to penetrate the mass.

The soft and vascular osteoid and newly formed skeletal connective tissue of os novum readily absorbs nutrition and forms new bone. Because of its softness, it can be shaped easily and without injury to fit the new bed, and it is better tolerated by the soft tissues than is fresh, mature, hard bone. Scarred, eczematous skin, for example, which is often present over a pseudarthrosis, does not seem to be so greatly irritated by os novum as by hard bone.

At first, os novum gives only slight mechanical support, and cannot, therefore, be used for the internal fixation of bone parts. Since it is easily nourished and has great proliferative power, it is suitable for cases in

hich rapid new bone formation is desired, and where fresh material should ot be taken from the skeleton itself, as, for example, in children with elicate bony framework. If increased internal fixation is desired, a comnation of os purum and os novum may be used.

Os purum has a technical advantage in that it can be kept on hand in dry form and sterilized by the usual heating methods, preferably by oiling in physiological salt solution. This dissolves a part of the collaenous gluelike material, thereby making the material softer and easier to andle. It may be obtained in various sizes and can easily be given the esired shape with the help of hand- and motor-driven tools.

I have repeatedly demonstrated that all three types of grafting maerial described can be used to advantage in various surgical procedures. have been able here only to describe very briefly a few ways of employing hese new grafting materials and the principles governing their use. It is, f course, as yet impossible fully to evaluate these materials. It will take nuch time and work before we can determine in detail exactly when and ow to use them. I hope that research along this line will provide us with icreased knowledge of the nature of bone formation to the benefit of bone urgery and surgery of the extremities in general.

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THE INFECTIOUS ORGANISM IN OSTEOMYELITIS *

Part I. The Bacteriology of Bone Infection †

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On February 14, 1880, the eminent orthopaedic surgeon, Lannelongue, invited Louis Pasteur to be present at the Hôpital Sainte-Eugénie while he operated on a girl of twelve years, who presented a closed swelling of the right leg, knee, and lower thigh. A long incision released abundant pus. The tibia was found to be denuded over a long stretch. Three openings made in the bone released pus welling up from each. Samples of pus taken by Pasteur himself from all of these sources showed under the microscope packets of the microbe of furuncle and from each sample were grown cultures typical of the microbe of furuncle. In this case, therefore, the osteomyelitis was essentially a furuncle of bone and bone marrow. In reporting this pioneer observation, Pasteur suggested that it should be easy to produce osteomyelitis experimentally in living animals.

Rosenbach, Becker, and Feodor Krause confirmed this observation. Becker injected the microbe, which we now call staphylococcus aureus, intravenously into experimental animals in which he fractured or contused the bones and was able in this way to produce suppuration of bone at the site of injury. Krause also succeeded in producing bone suppuration in rabbits and guinea-pigs by a similar technique. He has described the lesions of other tissues observed in these experimental animals, in particular the very frequent renal abscesses in the rabbit, and the occasional suppurating joints. This careful observer concluded that the disease which he produced experimentally resembled the pyaemia of man rather than the common typical human osteomyelitis.

Rodet, in 1884, was the first to produce, by experimental intravenous injection of staphylococci into young rabbits, without physical trauma, the juxta-epiphyseal necrotic and suppurative lesions of bone, so analogous to those of human hematogenous osteomyelitis as to be accepted as essentially the same. Confirmatory studies by many subsequent investigators have confirmed Rodet's findings and have established the fact that osteomyelitis is most commonly due to infection with staphylococcus aureus. However, other bacteria are at times concerned in the infection of bone. The work of Lannelongue and Achard may be mentioned especially in this connection. At present we may say that the yellow staphylococcus is the microbic cause of more than half the cases of osteomyelitis,

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while an appreciable number of cases are caused by the staphylococcus albus, the streptococcus hemolyticus, the pneumococcus, the typhoid and paratyphoid bacilli, the tubercle bacillus, and the spirochete of syphilis; very rarely, by other microbes as, for example, the meningococcus.

In general one may observe somewhat different clinical peculiarities in the course of the disease, depending upon the type of the infecting microbe. However, the variations in the clinical picture which may be observed in staphylococcic osteomyelitis alone are so marked and so confusing that the careful student will require bacteriological evidence for his decision. Garrè has given special attention to the exceptional forms of the disease and has shown that the yellow staphylococcus may cause an albuminous periostitis, a subacute osteomyelitis, a sclerosing non-suppurative osteomyelitis, a bone abscess which may heal spontaneously, a recidivous osteomyelitis after an interval of twenty years or more, and a primary osteomyelitis of adults, as well as the more common acute osteomyelitis of children. One should not neglect the opportunities for bacteriological study of these lesions, the results of which furnish an aid to prognosis and a guide to treatment.

The exact course of events leading up to the destruction of bone by the staphylococcus has not yet been fully ascertained, although considerable debate and some careful experimental study have been devoted to this matter. Pasteur, in 1880, pointed out that the staphylococcus appeared unable to grow in the circulating blood. When he injected it intravenously into guinea-pigs, the animals remained well and the microbes were eliminated from the blood or digested. However, he felt sure that the germs could be transported in the blood to a new site for development and he was of the opinion that cultures of the blood in cases of human staphylococcic infection, made by using several grams instead of drops of blood, would disclose the occasional presence of these microbes in the circulating blood.

Lexer, in a series of important papers, concluded that the localization of bacteria at certain places in bone depended upon trauma and upon structural features of the epiphysis associated with the active growth of bone. He was able to confirm the results of Rodet and of Lannelongue and Achard in experiments on young rabbits. Lexer thought that the purulent foci in the bone were of embolic origin, the embolus coming from thrombophlebitis at the primary site of infection, a view which was still accepted by Wilensky in 1934.

Josef Koch has shown that, in children dying of infectious diseases such as measles, diphtheria, pertussis, scarlet fever, or gastro-enteritis, the epiphyses of the bones quite regularly harbor streptococci, staphylococci, and colon bacilli and, occasionally, other organisms. By experimentation on mice and on young rabbits, he convinced himself that the localization of the bacteria at these sites was a result of favorable conditions for their survival and growth and was not to be explained by mechanical factors causing them to lodge there from the circulating blood. In

fact, the bacteria injected into the blood lodged in abundance in the bone marrow of the shaft, but in this location the microbes were destroyed, while they were able to survive at the epiphyses.

Several experimental investigators have challenged some of the ideas of Lexer. Especially important is the investigation of Hobo. He points out that pulmonary abscesses are absent in human osteomyelitis and usually absent in experimental osteomyelitis, and one might expect that infected emboli would be caught in the pulmonary capillaries before reaching the bones. He also exposes the fallacy of the mechanical theories. Foreign particles in the blood do not just settle where the current is slow, but they are actively phagocytosed in the spleen, the liver, and the bone marrow. Intravenous injection of India ink into rabbits caused the visible mucous membranes to become dark almost immediately, but these bleached out again in about ten minutes. When the animals were killed after forty-five minutes, the liver, the spleen, and the entire bone marrow were intensely black, while the other organs showed no macroscopic changes, although a few pigmented thrombi were found in them microscopically. In the liver, the spleen, and the marrow the ink particles were largely phagocytosed within the endothelial cells. In the marrow the capillary endothelium was full of ink particles, and wandering cells, lying on the capillary walls, were full of the particles. These ink deposits were always found in the venous capillaries and never in the terminal arterioles. Always the marrow of the metaphysis contained less ink than the marrow of the shaft. However, at the curve of the capillary loop in the metaphysis there were clumps of ink particles without efficient phagocytosis. These observations, which are in accord with those of J. Koch, Dumont, and Kusama, require the consideration of biological factors of tissue resistance rather than a mere mechanical explanation for the common localization of bacterial infection at the metaphysis of growing bone. It seems significant that the spleen, the liver, and the shaft marrow, in which early accumulation and phagocytosis of circulating foreign particles and bacteria are most abundant, are locations which escape the later abscesses, while the metaphysis of growing bone and the renal substance are the favorite sites for abscess formation.

These pathological and experimental observations are fundamental to an understanding of the course of events in the body of a patient with hematogenous osteomyelitis, and a clear understanding of their significance will aid the judgment of the physician in his decision in regard to treatment. The overwhelming invasion of the blood stream by virulent staphylococci from an active suppurating focus must be regarded as a general infection, in which the painful spot in a bone is merely one localization of minor importance,—a situation in which the patient is fighting for his life and will only be further depressed and endangered by ill-considered incisions and drillings. Radical operation upon children of this type is probably the most common serious error in the therapy of acute hematogenous osteomyelitis at the present time. When the infection of

the blood stream has been of a milder character, so that it has been overlooked and the suppurating lesion in the metaphysis has appeared following strain or local trauma or some other depressing experience, the infectious agent is usually of diminished virulence and the host resistance is relatively high. There is little real excuse for the panic which results in hasty, ill-considered operation on these patients. Considerable progress has been made in surgery since Murphy taught: "*In acute osteomyelitis operate it at once*" and "*But even if you should not find it* [*pus*] *there in an individual case you will have done the patient no harm by the mere trephining of the bone, and will have eliminated a source of worry for yourself.*" Starr did much to still the riot of radical surgery in this disease and the wise counsel of Dean Lewis gently but firmly favors conservatism. It is most significant that even younger men now dare to favor a less radical treatment of osteomyelitis in children. Thus Wilson and McKeever venture to say that survival of the patient may after all be a matter of some importance, that operative interference is often undertaken too early rather than too late, and that perhaps the answer to the problem is not the earliest possible surgical invasion of the bone, but a well-timed adequate drainage of the medullary canal when the individual's resistance is at the highest possible point. One also hears more frequent mention of the general factors of resistance to infection.

SUMMARY

1. Hematogenous osteomyelitis is due to the growth of bacteria which have reached the interior of bone by transport through the blood stream. Bacteria of various kinds may be concerned, but the staphylococcus aureus is responsible in most instances.

2. Localization of the disease process depends upon diminished resistance at particular sites, associated with growth activity at the metaphysis or with trauma at any place. In the absence of trauma, the marrow of the shaft is relatively resistant to infection because of the efficiency of its endothelial cells in the phagocytosis and destruction of bacteria.

3. A consideration of the bacteriological relationships indicates the wisdom of a conservative attitude in dealing with acute hematogenous osteomyelitis.

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THE INFECTIOUS ORGANISM IN OSTEOMYELITIS *

Part II. Bacteriophage and Serum Therapy †

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In the second part of this paper, the author wishes to mention briefly some of the general measures for combating infection in contradistinction to the local measures of incision and drainage. For some years we have been engaged in the study of the phenomenon of transmissible bacterial lysis and its possible application in the treatment of infections, and it is the purpose of this paper to discuss the bacteriophage phenomenon as we observe it in the bacterial culture, the technique of preparation of the material for use in animal experimentation and in human disease, the effect of these bacteriophage agents in animals, and their effects when administered intravenously to patients with osteomyelitis.

The mysterious destruction of cholera germs by the waters of the River Jumna at Agra, India, was recorded by Hankin in 1896, but there still remains some uncertainty in regard to the nature of the destructive agent. Twort, in 1915, observed the solution of bacterial colonies on solid media and was able to show that this transmissible dissolution of bacteria was caused by a filterable virus. Subsequently d'Herelle recognized the solution of cultures of the Shiga bacillus by a filterable agent, to which he gave the name of bacteriophage, and he has been able to extend these observations so as to recognize the phenomenon of transmissible bacteriolysis in many microbic species and to apply these observations in the treatment of diseases of animals and of men.

The bacteriophage phenomenon as observed in the laboratory is well illustrated by mass cultures on agar plates. For example, one may inoculate a solidified agar plate by spreading a broth suspension of the colon bacillus over the surface; then one adds a suitable amount of a potent bacteriophage filtrate to the broth suspension and inoculates a second agar plate by spreading this mixture over the surface. These two plates are then incubated together. After a suitable interval, if the mixtures have been fortunate, one is able to observe moth-eaten spots in the confluent growth of the second plate, while the first one shows the usual mass culture of bacterial growth. Such an experiment is illustrated in Figures 1-A and 1-B, which are taken from a previous publication of Miss Frances C. Frisbee of our laboratory. The phenomenon may also be illustrated on agar slants by drawing a wire wet with the bacteriophage along the center

* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons, Cleveland, Ohio, January 12, 1937.

† Aided in part by a grant from the Josiah Macy, Jr. Foundation.

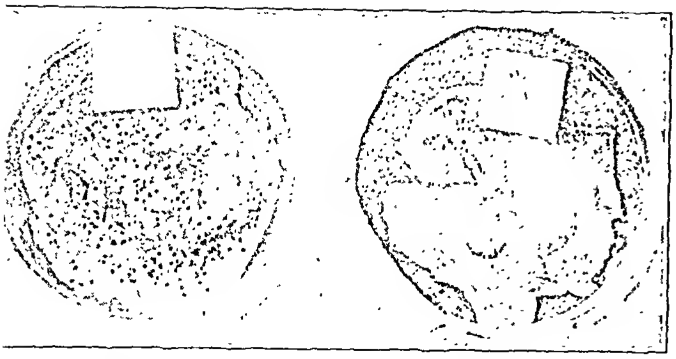
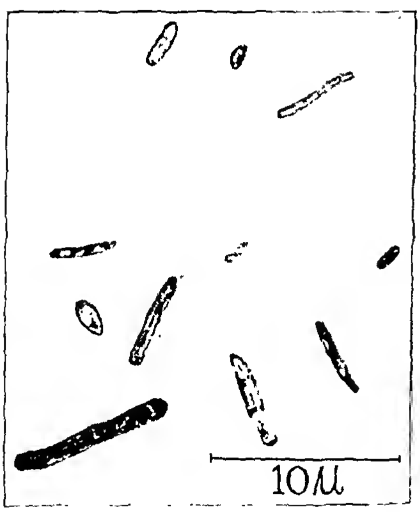


FIG. 1-A FIG. 1-B

The agar plate in Fig. 1-A was streaked with a bacterial pension to which a small amount of bacteriophage had en added. The clear areas in the growth represent cteriophage plaques. The agar plate in Fig. 1-B is a ntrol plate streaked with the bacterial suspension to ich no bacteriophage was added. (*Courtesy of Archives Ophthalmology.*)[12]

of the slant after it has been inoculated with the susceptible bacteria. In liquid media, one obtains a sharp contrast because the culture tube inoculated with the bacteria alone becomes diffusely clouded, while that which has been inoculated with the bacteria and the bacteriophage begins to cloud and then becomes entirely clear as no growth had ever taken place. Such cultures in liquid media serve t only to illustrate the phenomenon, but the cleared culture, when filred, furnishes the usual bacteriophage preparation which is employed r further experimentation in laboratory cultures and in therapy. The anges taking place in the bacterial cells in such a dissolving culture have en studied by numerous observers and we know that the individual cterial cell tends first to swell and then it quite suddenly bursts and sses into solution. Such swollen and disintegrating bacterial cells in a lture of Asiatic cholera subjected to bacteriophage lysis are illustrated Figures 2-A and 2-B.

The effect of the bacteriophage in the internal tissues of the body is evidently somewhat different from the effect observed in the test tube. The swelling and bursting of the bacteria



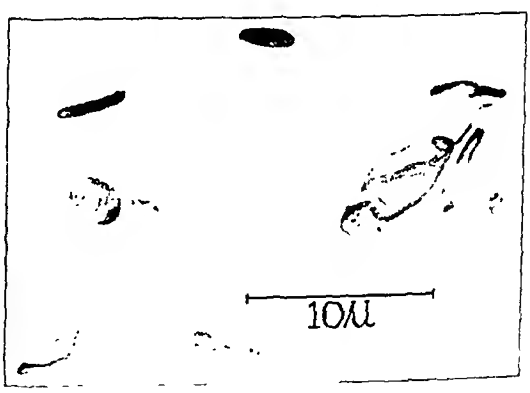


FIG. 2-A FIG. 2-B

Stained preparation of sediment from test-tube cultures of cholera germs incubated with cholera bacteriophage for four hours. The smallest bacteria represent the normal size and shape of the cholera germs. Note that many individuals are enormously swollen. In Fig. 2-B, many of them have absorbed water from the medium and are about to disintegrate completely.

have not been observed there. On the other hand, we have been able to show that the intravenous injection of potent bacteriophage into rabbits, subsequent to their intravenous inoculation with the susceptible bacteria, is followed by a more active and efficient phagocytosis of these bacteria by the endothelial cells of the spleen and liver and also by a more prompt intracellular digestion of these phagocytosed bacteria.[8] In the animals receiving the injections of bacteriophage there was a relative protection of the various organs from localization of the infectious agent. The appearance of endothelial cells of the liver in such experimental animals is illustrated in Figure 3.

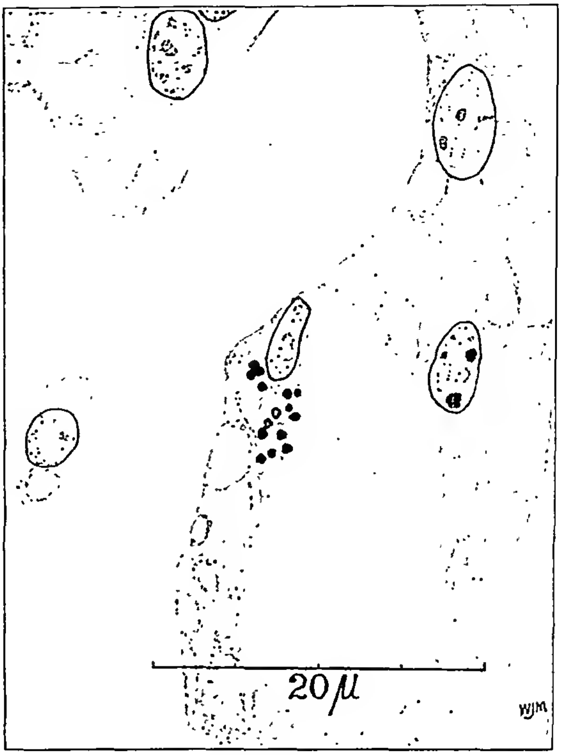


FIG. 3

Phagocytosed bacteria in an endothelial cell of rabbit liver fixed in the distended state after perfusion. This phenomenon of phagocytosis is favored by the presence of staphylococcus bacteriophage in the blood.

The effect of the bacteriophage in such instances is to aid the body defenses against the bacterial invader.

The effect of bacteriophage in the treatment of accessible local infections is exemplified by the treatment of carbuncles. Figure 4 shows the back of an infant who had enormous carbuncles on the buttocks. These were treated by needling with staphylococcus bacteriophage, with an excellent result. The picture was taken about two weeks after beginning the bacteriophage therapy. In another patient, L. S., a suppurating cellulitis of the left hand, with accumulation of pus in a bursa on the back of the hand, was treated by aspiration of the bursa and irrigation with

FIG. 4

Photograph of the buttocks of a baby, taken on May 22, 1931, after local bacteriophage treatment of enormous carbuncles from May 5 to May 12. (*Courtesy of New York State Journal of Medicine.*)[3]

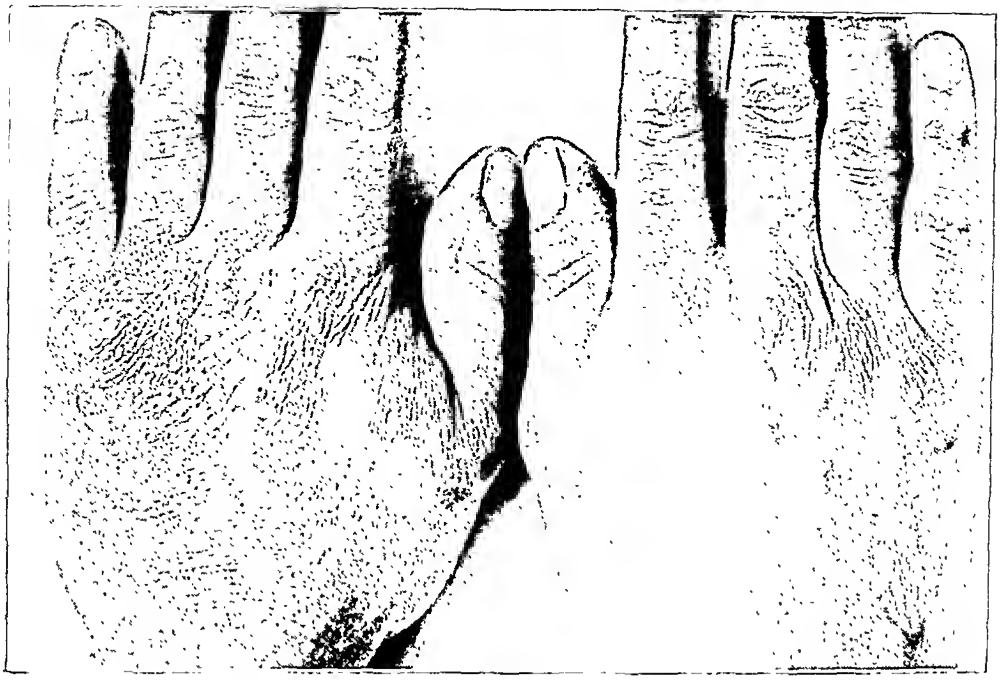


Fig. 5-A

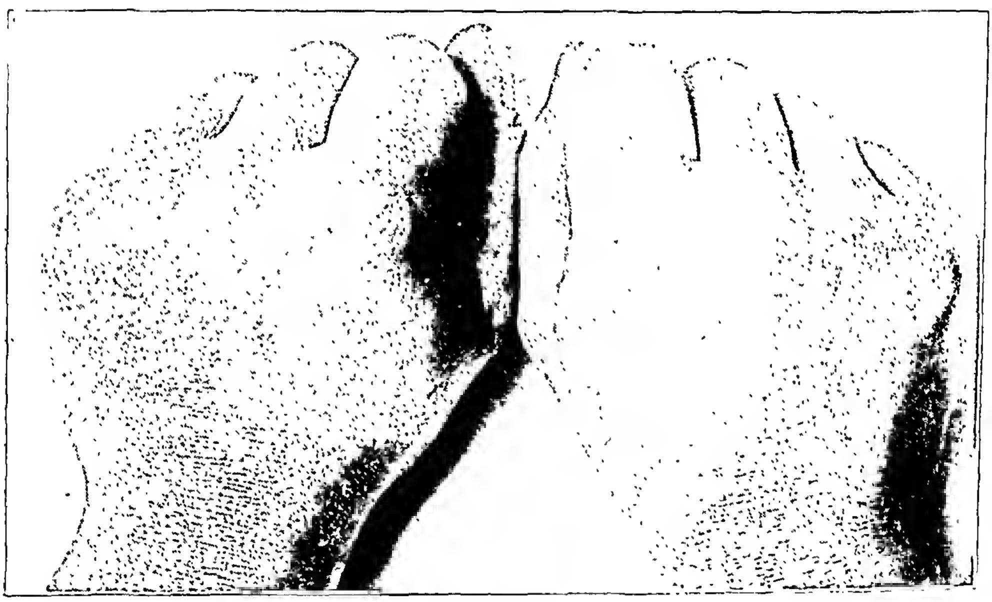


Fig. 5-B

Hands of L. S., photographed March 29, 1933. The site of most severe earlier inflammation is indicated by the thickened skin. On March 6, 1933, the patient presented himself with a fluctuating prominence surrounded by a swollen red area covering the dorsum of the left hand. Aspiration obtained thick hemorrhagic pus which, on culture, yielded staphylococcus aureus. On March 8, the cavity was again aspirated and irrigated six times with bacteriophage, and was left in the collapsed state. This treatment was repeated on March 10 and 13. On March 15, the cavity was punctured with two needles and washed through with six cubic centimeters of asparagin bacteriophage. This treatment was repeated on March 16, 17, 18, and 20. The fingers were fixed by a wooden splint until March 18, but after that time free movement was permitted. Cultures of the thin exudate obtained on March 20 remained sterile. The patient also received immunizing doses of one cubic centimeter of bacteriophage into the deltoid region on March 6, 10, 15, 22, and 25. He continued to work all the time, and the functional result has remained perfect. (*Courtesy of American Journal of Medical Sciences.*)[4]

staphylococcus bacteriophage during a period of eighteen days. As a result, the lesion healed without incision, deformity, or disability. Figures 5-A and 5-B illustrate the condition of the hands of this patient at the end of four weeks.

In our papers on staphylococcic septicaemia [5, 6, 7] we have presented summarized records of several patients in whom a septicaemia was associated with osteomyelitis. In general, the intravenous administration of the bacteriophage has exerted some influence in protecting the skeleton from metastatic localizations of the infection, but in those instances in which an operation had already been performed upon the bone the patients appeared not to do so well. In several instances we have had to deal with patients in whom there was an infection not only with the staphylococcus but also in combination with the hemolytic streptococcus. In such instances we have employed staphylococcus bacteriophage and a concentrated antistreptococcus serum to combat the double infection. One of these cases has been made the subject of a special report.[9]

The report of another patient with double infection is presented here.

E. F., male, aged eighteen months, came to the Hospital with a swollen and painful right wrist on April 21, 1935. The blood culture on admission was negative. On the next day, April 22, the wrist was incised and the incision was carried through the periosteum, releasing some exudate. Blood culture, taken a few hours after this operation, revealed staphylococcus aureus in the blood stream and the exudate from the operative incision also yielded the same organism. The clinical course of this little patient is illustrated in Figure 6. The dressings were displaced on April 24 so as to expose the

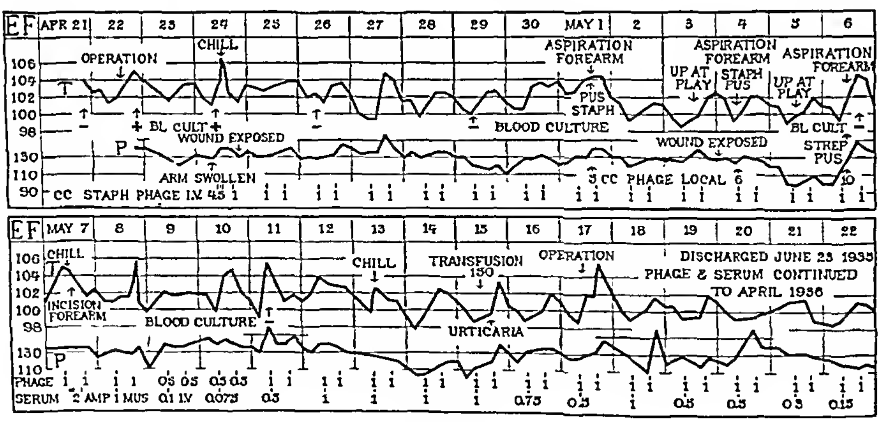


Fig. 6

Abbreviated clinical record of E. F., male, aged eighteen months. This baby was operated upon on April 22, 1935 by incision of the right wrist passing through the periosteum of the ulna. Immediately after the operation, blood culture was taken, which gave positive growth of staphylococcus aureus. Staphylococcus bacteriophage was administered intravenously beginning on April 24. Blood culture became negative forty-eight hours later. Secondary infection with streptococcus hemolyticus was recognized on May 6, and streptococcus serum was given along with the staphylococcus bacteriophage from May 7, 1935, to April 1936. The soft parts of the forearm were incised on May 7, 1935, for drainage. The child has made a complete recovery. (See Figs. 7 through 20.)

Fig. 7 April 22, 1935 — Fig. 8 April 22, 1935 — Fig. 9 April 27, 1935 — Fig. 10 May 7, 1935 — Fig. 11 June 7, 1935 — Fig. 12 July 9, 1935

A series of roentgenograms of the forearm of Patient E. F. The right wrist was incised on April 22, 1935, and the right forearm was incised on May 7, 1935. Note the progressive alteration of the ulna.

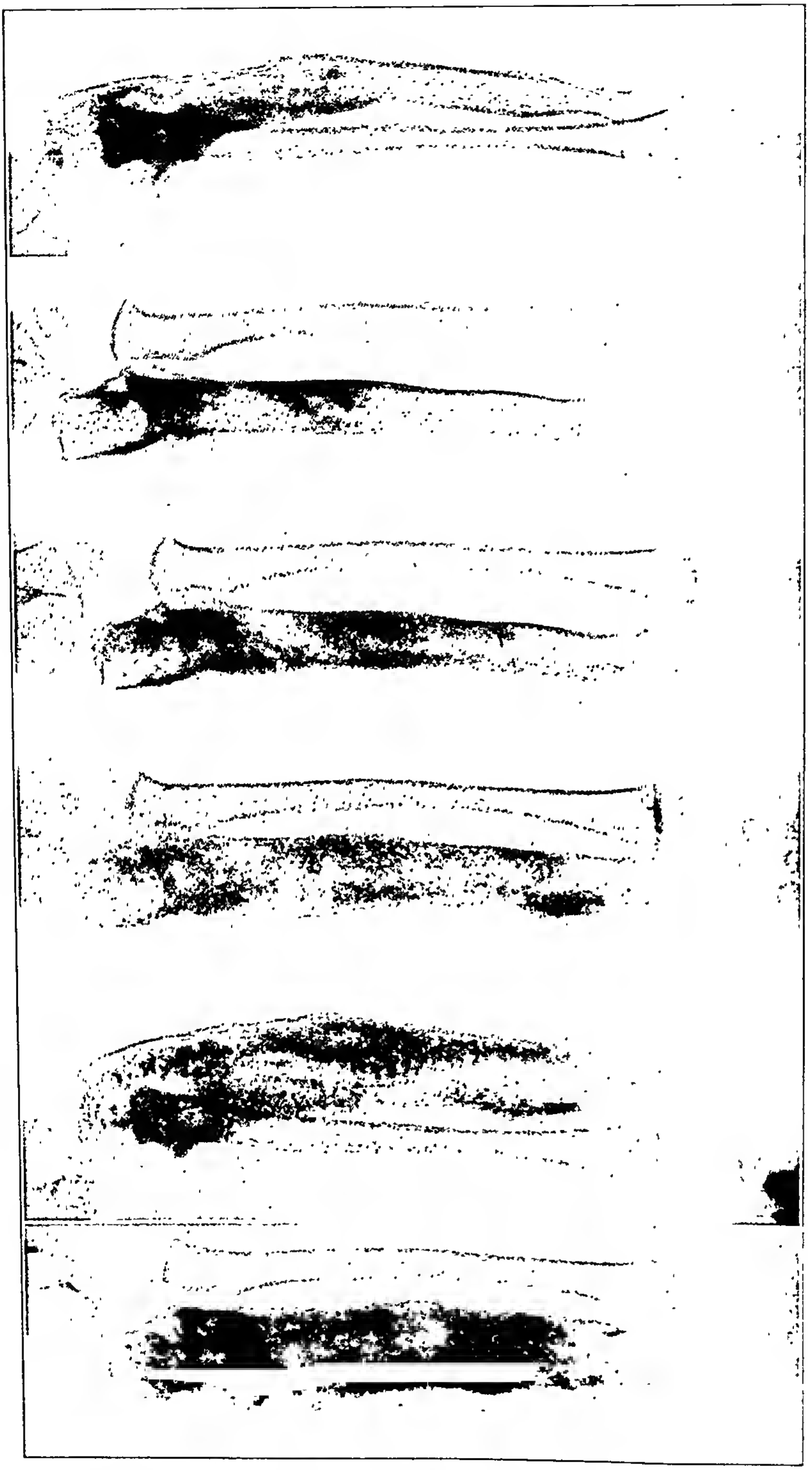


Fig. 13 — August 8, 1935
Fig. 14 — September 9, 1935
Fig. 15 — November 6, 1935
Fig. 16 — January 7, 1936
Fig. 17 — March 17, 1936

A series of roentgenograms of Patient E. F., showing progressive stages in the healing of the right ulna. On March 17, 1936, this bone was quite dense, but there was evidence of a defect at the distal end.

Fig. 18

Patient E. F., September 9, 1935, showing alteration of the right femur in the region of the greater trochanter and below it. The disability cleared up entirely without local treatment.

surgical wound. The swelling of the forearm continued to extend, and an aspiration of the upper part of the forearm on May 4 yielded pus containing staphylococci; a subsequent aspiration on May 6 yielded pus containing streptococci and staphylococci. The forearm was incised for drainage of the soft tissues on May 7. The patient received staphylococcus bacteriophage intravenously beginning on April 24 and streptococcus serum beginning on May 7. The injections of these agents were continued to April 1936.

Fig. 19

Patient E. F., April 14, 1936. The surgical incisions are entirely healed and there is no disability.

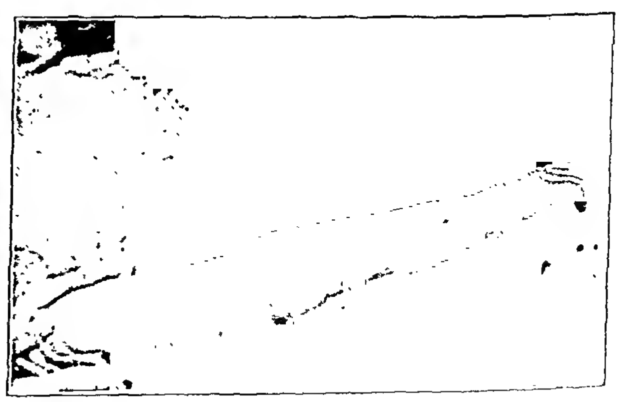


Fig. 20

Patient E. F., April 14, 1936. Note the perfect extension and function of the hand. This patient has since continued in excellent condition.

Roentgenograms of the forearm were made from time to time. Figures 7 and 8 are roentgenograms taken on April 22, 1935, just preceding the first operation. There is only slight suggestion of change at the lower end of the ulna. Figure 9 shows the condition on April 27, five days after operation. The roentgenogram shown in Figure 10 was taken on May 7, 1935. Roentgenograms taken at approximate intervals of one month record the changes in the bone. Figure 11, showing the condition on June 7, 1935, suggests that complete destruction of the ulna was to be expected. However, Figures 12 and 13, roentgenograms of July 9 and August 8, indicate beginning limitation of the inflammatory process. On September 9 (Fig. 14), the ulna appears to be more clearly defined. On this date, because of a limp, a roentgenogram of the hips and pelvis (Fig. 18) was taken, disclosing a defect near the greater trochanter of the right femur. This lesion was neglected and has receded entirely. The roentgenogram of November 6 (Fig. 15) shows a more sharply defined ulna, and on January 7, 1936 (Fig. 16) there is evident still further progress of healing. On March 17 (Fig. 17), the ulna appears abnormally dense and, although somewhat enlarged, has assumed a reasonably normal contour. The lower end is, however, deformed and evidently there has been some injury to the epiphyseal cartilage in this location. Figures 19 and 20 show the healed forearm and the freedom of movement. At the present time this patient is quite free from any disability and uses this forearm by preference rather than the other. The lesion of the femur no longer gives any symptoms.

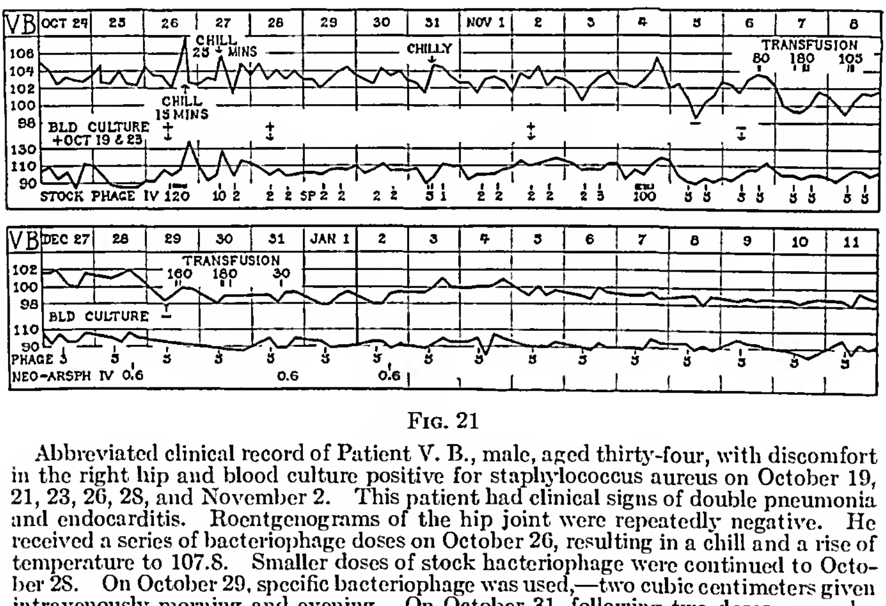


Fig. 21

Abbreviated clinical record of Patient V. B., male, aged thirty-four, with discomfort in the right hip and blood culture positive for staphylococcus aureus on October 19, 21, 23, 26, 28, and November 2. This patient had clinical signs of double pneumonia and endocarditis. Roentgenograms of the hip joint were repeatedly negative. He received a series of bacteriophage doses on October 26, resulting in a chill and a rise of temperature to 107.8. Smaller doses of stock bacteriophage were continued to October 28. On October 29, specific bacteriophage was used,—two cubic centimeters given intravenously morning and evening. On October 31, following two doses—namely, two and three cubic centimeters given intravenously—the patient felt chilly and his temperature rose to 104.6. On November 4, a series of doses of bacteriophage to a total amount of 100 cubic centimeters was followed by a rise in temperature to 105.4 and by a fall the next day to 98.6. This appears to have been a bacteriophage reaction, and the blood culture taken on November 6 remained negative. Human blood was given in divided doses on November 6, 7, and 8. Subsequent blood cultures on November 9, 13, 24, December 10, and December 29 remained sterile. Sixth-tenths of a gram of neoarsphenamine in water was given intravenously on November 14, 19, 25, December 2, 5, 10, 12, 14, 16, 18, 20, 22, 24, 28, 30, and January 2. The condition of the heart and the lungs became quite satisfactory, but the discomfort in the right hip continued. On November 25, periosteal thickening was recognized along the inner border of the right ilium by palpation. The chart shows the temperature and pulse to December 11. Since that time the daily bacteriophage doses have been continued. The patient now appears to be convalescent.

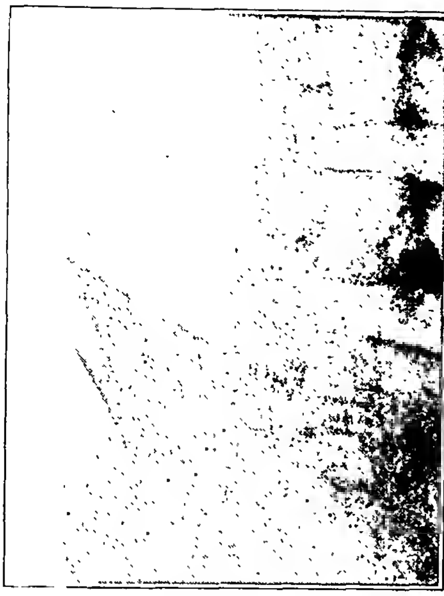


FIG. 22

Roentgenogram of right iliac crest of Patient V. B. on November 28, 1936. Note alteration of internal border of iliac crest.

FIG. 23

Roentgenogram of right ilium of Patient V. B. on January 2, 1937. Note alteration near the crest of the ilium in the area of the gas bubble within the intestine.

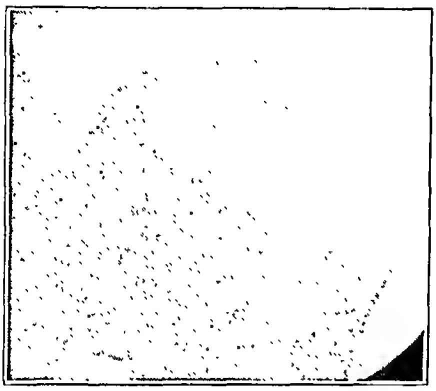


FIG. 24

Roentgenogram of right ilium of Patient V. B. on January 6, 1937. Alteration near the iliac crest is still evident.

Another patient now under observation in the hospital may serve as a further illustration of bacteriophage therapy in hematogenous osteomyelitis.

V. B., male, aged thirty-four, was admitted to the Hospital on October 16, 1936. He is a professional acrobat and a trapeze artist. His chief complaint on admission was pain in the right hip, which had been present for two days. This followed a cold which he had had for about a week. The pain was so severe that he had been confined to bed. Physical examination revealed a soft systolic murmur at the base of the heart and a slight limitation of motion of the right hip upon medial rotation of the thigh. The other movements of the hip joint were free. He presented a puzzling diagnostic problem, and for the first two weeks it was thought that a low-grade pneumonia was the essential condition present. However, inasmuch as his temperature remained high (104 to 106), blood cultures were taken on October 19, 21, and 23. All of these gave a positive growth of staphylococcus aureus developing rather slowly. Figure 21 shows part of his abbreviated clinical record from October 24 to November 8, inclusive, and again from December 27 to January 11, 1937, inclusive. On October 26, it was decided to give him intravenous bacteriophage treatment and he received 120 cubic centimeters of stock staphylococcus asparagin bacteriophage in divided doses beginning at 10:30 a.m. and ending at 6:30 p.m. About half an hour later the patient had a chill, which lasted for fifteen minutes, and at the end

of the chill his temperature reached 107.8. On the next day bacteriophage was continued—ten cubic centimeters at 9:40 a.m. and two cubic centimeters at 4:15 p.m. On October 28, the blood culture was again taken, and small doses of bacteriophage were given morning and evening. On October 29, specific bacteriophage, prepared from the patient's own blood culture, was substituted for the stock bacteriophage previously used, and this was given in small doses morning and evening on October 29 and 30. The blood culture, taken on October 28, now showed a positive growth, and it was decided to attempt to produce another shock by a series of bacteriophage doses. On October 31, the patient was given two cubic centimeters of specific bacteriophage at 8:50 a.m. and three cubic centimeters at 11 a.m. He then complained of feeling chilly, and no further doses were given until 4 p.m. The temperature rose to 104.6, but the reaction was not a satisfactory one. Blood culture, taken on November 2, was again positive, and, on November 4, another series of doses of bacteriophage were given in the attempt to produce a shock, the total amount of bacteriophage being 100 cubic centimeters. He did not develop a frank chill, but his temperature reached 105.4 and subsequently descended to 98.6 at noon on November 5. This behavior suggested a fairly satisfactory reaction to the bacteriophage, but its atypical character tended to support the tentative diagnosis of vegetative endocarditis. In fact, at this time the heart was enormously dilated and there was a quite distinct mitral murmur. Blood culture, taken November 6, remained negative. The patient was given small intravenous injections of citrated human blood on November 6, 7, and 8, and the doses of bacteriophage were continued morning and evening in amounts of five cubic centimeters. Subsequent to November 8, the patient had negative blood cultures taken on November 9, 13, 24, and December 10 and 29; these all remained negative. Because of the tentative diagnosis of endocarditis, six-tenths of a gram of neoarsphenamine was given intravenously on November 14, 19, 25, December 2, 5, 10, 12, 14, 16, 18, 20, 22, 24, 28, 30, and January 2. Bacteriophage treatment was continued during this time. The condition of the heart and lungs became much more satisfactory, but the patient became emaciated and extremely weak, being unable to turn himself in bed, and the care of the skin became a serious problem. The lower half of Figure 21 shows the chart from December 27. It is evident that the temperature had already assumed a lower level and after December 29 it no longer approached 102. Bacteriophage doses had now been reduced to one per day and, because of the development of numbness of the hands and feet, neoarsphenamine was discontinued after January 2. The patient has continued to convalesce slowly.

The condition of the right hip was subjected to roentgenographic study, but it was impossible to find any evidence of alteration in the femur or in the hip joint. About November 20, the patient complained of tenderness over the crest of the right ilium, and subsequently muscle contracture prevented the extension of the right thigh. By November 25, a firm tender mass, extending along the inner border of the right ilium, could be palpated, but there was no evidence of pointing at any spot. A tentative diagnosis of osteomyelitis of the ilium has been supported by roentgenograms taken on November 28, 1936, and January 2 and 6, 1937. (See Figures 22, 23, and 24.) Along with the evidence of osteomyelitis of the iliac crest there have been marked swelling of the right inguinal lymph nodes, a very marked oedema of the scrotum, and slight oedema of the right foot and ankle. This local condition in the ilium has greatly improved. The scrotal oedema and the oedema of the foot have entirely disappeared, and the swollen lymph nodes have diminished considerably in size. Tenderness along the iliac crest has entirely disappeared, but the periosteal thickening can still be recognized by palpation in this region. We are very hopeful that this patient will make a complete recovery without incision.

These cases may serve to illustrate what can be accomplished by conservative use of biological and chemotherapeutic agents to assist general resistance to infection of bone.

Figure 25 suggests the mode of transport of staphylococci in the

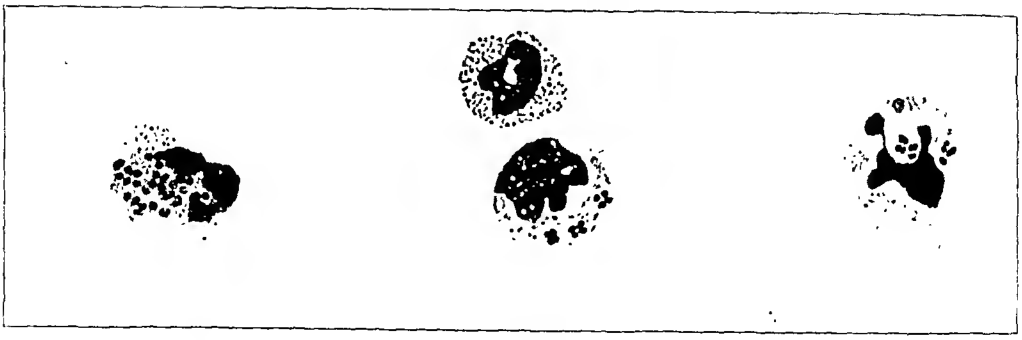


Fig. 25

Phagocytosed staphylococci in the circulating blood of Patient F. B. approximately twelve hours before death from severe staphylococcic sepsis. The blood culture taken at this time showed over 5,000 colonies of staphylococcus aureus per cubic centimeter of blood.

circulating blood. This picture represents leukocytes seen in a film of blood taken from the finger tip of a patient, F. B., with severe staphylococcic sepsis about twelve hours before his death. We have been unable to identify any staphylococci free in the blood plasma. It is, however, quite easy to find them within the polymorphonuclear leukocytes. A similar observation of phagocytosed bacteria in the circulating blood has been made by others, notably by Simon and by Pepper and Farley. In our patient the blood culture taken at the same time yielded approximately 5,000 colonies of staphylococcus aureus per cubic centimeter of blood. Here we have a visible demonstration of one mode of transport of bacteria in the circulating blood.

SUMMARY

1. The filterable agent of transmissible bacteriolysis causes solution of the respective bacteria in watery culture media. In the circulating blood of the living animal it apparently fails to cause such solution, but exerts an opsonic effect, favoring more effective phagocytosis.

2. When properly employed, such a lytic agent brings aid to the body defenses in overcoming infection with the staphylococcus, not only in furuncles, carbuncles, and septicaemia, but also in the bone lesions of staphylococcic osteomyelitis.

3. Staphylococci have been observed within polynuclear neutrophilic leukocytes of the circulating blood.

The author wishes to thank Dr. William H. Meyer, Professor of Roentgenology, for his cooperation, and also his various colleagues in the Department of Pathology and Bacteriology, who have carried the chief burden of this work.

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MALUNION OF FRACTURES AND DEFORMITIES OF LONG BONES

An Improved Technique for Correction by Osteotomy

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When a complete transverse osteotomy of a long bone is performed by some of the customary methods, there is danger of displacement of the fragments, or, in some cases, of non-union at the site of osteotomy. Deformities of long bones occur chiefly as a result of fractures with malunion, of deficiency diseases such as rickets, of osteomyelitis, and of anterior poliomyelitis.

The problem has been to devise an operation which will correct the deformity and at the same time maintain continuity of the bone. Theoretically, a greenstick fracture at the site of the angulation, by making correction manually, would satisfy the requirements if such a procedure were practical. In former times this was done to correct genu valgum by forcibly making a manual epiphyseal fracture at the distal extremity of the femur by the procedure known as epiphyseolysis.[1] Fear of growth disturbances and other complications has caused this method to become obsolete.

The writer has worked out an osteotomy by which deformities can be corrected without loss of continuity of the bone. Briefly, the operation consists of the excision of a section of bone, resembling a truncated wedge, at the site of the angulation or deviation. The osteotomy extends two-thirds or four-fifths through the bone transversely, the distance depending on the density of the bone tissue. After this section has been excised, the mass of bone in the cross-section at the site of the operation is reduced in size, so that only moderate manual force is required to bend it and produce an incomplete or greenstick fracture. In the correction of the deformity this incomplete fracture is produced by closing the space from which the truncated wedge is removed.

A mechanical explanation of the procedure is as follows: The column of bone which maintains continuity after the excision of the truncated wedge has sides of almost equal length. The manual force used to correct the deformity is applied to this column. As the space is closed and correction is made, the bone column is partially crushed and impacted into itself, so that continuity is maintained.

The mechanics involved are changed considerably if a simple wedge osteotomy, extending part of the distance transversely through a bone, is performed, for, when an attempt is made to correct the deformity manually, a fulcrum is established at the angle of the wedge-shaped space.

Excision of the simple wedge also results in the necessity for a much greater force to correct the deformity manually, and, therefore, such an osteotomy must extend a greater distance transversely through the bone. Forcible correction will produce a complete fracture and loss of continuity of the fragments, with danger of displacement.

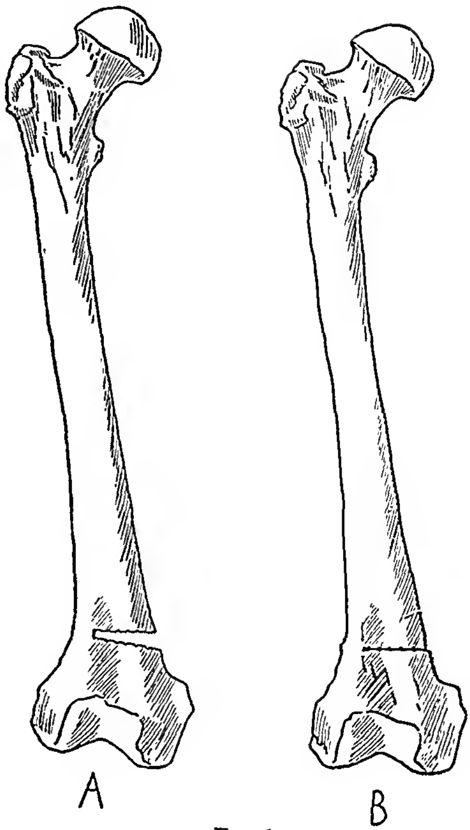

FIG. 1

A: Diagram of femur, illustrating deformity in a case of medial angulation of the knee, with truncated wedge of bone excised.
B: Correction by incomplete fracture of bone column, which maintains continuity, with closure of space.

TECHNIQUE OF OPERATION

To estimate the size of the truncated wedge of bone to be excised, a long roentgenogram, centered on the point or angle of deviation, should be made. For example, in a case of genu valgum, a film, seven by seventeen inches, may be used. With the roentgenogram on a viewing box, a tracing of the bone outline is made on thin paper. The outline tracing of the bone is cut out with scissors. By cutting the paper figure at the point of deviation and straightening it, the size of the section of bone to be excised can be determined. In making this estimation, one must take cognizance of the fact that in roentgenograms there is some magnification of bones, depending on the thickness of the bone and the underlying soft parts.

In performing the operation, the bone at the site of the deformity is exposed. The periosteum is incised longitudinally and retracted on the outer side of the angle of deviation by retractors which separate the soft parts from the bone. The outline of the truncated wedge of bone to be excised is marked on the bone surface. A sharp punch is used to mark for drill holes every six millimeters along this outline. Small holes are drilled through the bone at these punch marks, the soft parts on the deep side of the bone being protected by retractors. The osteotomy is performed with a very thin, sharp chisel or osteotome. The drill holes prevent splintering of the bone. After the truncated wedge of bone has been removed, the space is closed manually by an incomplete or greenstick fracture of the bone, which maintains continuity. In this way, the deformity is corrected without danger of separation of the fragments, and

healing of the bone is assured by the maintenance of a unified structure. Following the operation, immobilization of the part is maintained by a plaster cast which may be wedged if there is tendency toward recurrence of the deformity on account of tension by the soft parts. In cases where there are contractures and extreme shortening of the soft parts, it is necessary to lengthen them by tendoplasties, myotomies, or fasciotomies, as preliminary procedures before the osteotomy.

COMMENT

In malunion of fractures with angulation deformities, internal fixation is not necessary after osteotomy, except in malunited fractures of the forearm bones. Here, the tension of

FIG. 2

Case 5. Lateral view of left femur, showing fragmentation, displaced spicules of cortex, and malunion with anterior angulation deformity.

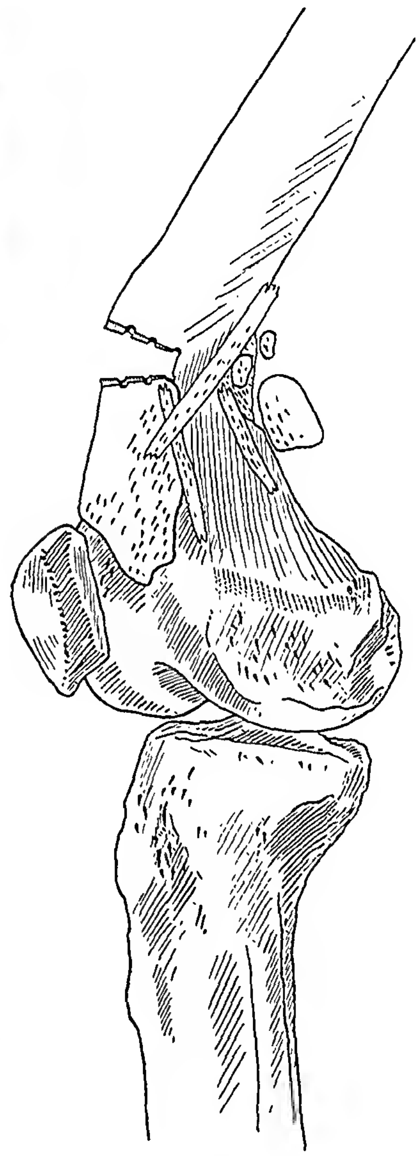

FIG. 3

Case 5. Diagram of lateral view, illustrating truncated-wedge osteotomy. Attention is called to narrowing of space medially for correction of lateral bowing.

the shortened muscles and soft structures will cause the deformity to recur partially after any osteotomy unless internal fixation is used, and the wedging of a cast in forearm deformities is usually impractical. However, the truncated-wedge osteotomy leads to quicker healing on account of the partial union which remains after operation.

In malunion of transverse fractures without overlapping, the excised truncated wedge consists chiefly of bone callus which has filled in the space between the fragments. It is obvious in these cases that no shortening is caused by the osteotomy. In deformities which result from other causes, the question of a small amount of shortening must be considered. However, the assurance of continuity of the bone with a minimum of shortening will usually outweigh this objection. In bilateral cases, as in genu valgum, the element of shortening is of no great importance.

In working out the details of this operation, it was considered originally that correction of deformities by this method could be made in one plane only. However, in Case 5, by making the truncated wedge thinner at its medial end, it was possible to correct both anterior angulation and lateral bowing of the femur.

Fig. 4

Case 5. Lateral roentgenogram of femur, three months after operation, showing satisfactory alignment of the anterior cortex. The appearance of loss of bone structure in the posterior cortex is due to fragmentation and splintering in the original fracture.

In malunited fractures with overlapping of the fragments, it is obvious that the problem is different and the rationale of treatment is changed, so that this operation does not apply.

The writer has performed this operation three times for post-poliomyelitis medial angulation deformity of the knee in which the deformity was chiefly in the femur.

In another such case, the osteotomy was performed on the tibia because the deviation was located in this bone. By this procedure also, correction of the deformity was made in malunion of an old fracture of the radius and in malunion of a comminuted fracture of the femur.

CONCLUSIONS

1. The axis of a long bone can be deviated by using manual force to make a greenstick or incomplete fracture when a cross-section of the bone is reduced in size by the excision of a truncated wedge of bone.

2. An osteotomy by excision of a truncated wedge transversely from a long bone at the site of a deviation deformity will permit correction manually by an incomplete fracture of the bone.

3. In malunited fractures with angulation deformities, this osteotomy prevents separation of the fragments and danger of non-union after correction.

4. Healing after a truncated-wedge osteotomy requires immobilization in a plaster cast for a minimum length of time, because there is not a complete loss of continuity and the circulation in the bone is disturbed less than after a complete osteotomy.

REFERENCE

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A PROCEDURE FOR STIMULATION OF LONGITUDINAL GROWTH OF BONE

An Experimental Study *

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Inequality in length of the bones of the extremities may result from one or more of a wide variety of causes which operate during the active growing period of the epiphyses. Either lengthening or shortening may result from the same etiological factors. The former follows irritative or stimulative lesions, and the latter follows destructive affections of the epiphyseal cartilage. In both the clinical and experimental fields, numerous observations have been made on this interesting subject.

CLINICAL OBSERVATIONS

Trauma: Injury of the epiphyseal cartilage plate may retard or actually arrest the growth of bone.[31, 32, 33] A classic example of arrested growth is seen in Madelung's deformity of the wrist, which follows after injury of the distal epiphysis of the radius. On the other hand, in overriding fractures of the shafts of long bones in children, the resultant shortening is usually equalized by a subsequent compensatory increase in length, and occasionally the affected bone actually becomes longer than the normal one.[7, 9, 36] This compensatory reaction probably results from some disturbance of the blood supply of the shaft, which, in turn, exerts a stimulative effect upon the growing ends.

Infection: In children various forms of infection cause disturbance of the growth of long bones. When the epiphyseal cartilage is destroyed by osteomyelitis, shortening results, but when the lesion is near the growing center, without actually involving it, lengthening often follows.[34, 35, 39] Shortening of the limb, as a result of tuberculous or pyogenic infection of a joint, is a very familiar observation; however, lengthening of the limb also may occur. Wagstaffe[37] reported twenty-five cases of chronic diseases of the knee joint in children. Growth disturbances occurred in 76 per cent. of the cases, with lengthening of the bones in most instances. The saber-shaped tibia of bone syphilis is sometimes definitely elongated, particularly when the infection is congenital.[15, 40] Also, infection of the soft tissue in the vicinity of the epiphysis may cause lengthening of the bone.[29]

Tumors: Of the various tumors of bone, chondroma is the one which commonly affects the growth and nearly always causes shortening.[38]

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Occasionally, in children, lengthening of the bones may be associated with soft-tissue neoplasms such as hemangiomata and multiple neurofibromata.

Vascular Disturbances: Lengthening of the bones has been reported as a result of several conditions which cause either active or passive hyperaemia. Horton[21] reported congenital aneurysm of the extremities in twenty-three cases, with lengthening of the bones in eighteen instances. Occasionally thrombophlebitis of long standing is followed by increased growth in the length of bones. Lengthening of the limb of the operated side has been observed after lumbar sympathectomy in cases of Hirschsprung's disease, spastic paralysis, and infantile paralysis.[16, 17]

Infantile Paralysis: Shortening of an extremity is commonly observed in infantile paralysis and is probably the result of atrophy of the muscles, with resultant lack of stimulation of the growth centers. Possibly altered circulation is also a causative factor.

Congenital Anomalies: Congenital hypertrophy may involve one entire side of the body, or one limb, or a single bone of the limb.[5, 26] Absence or underdevelopment of a bone or of an epiphysis occasionally is accountable for shortening of an extremity.[12, 25]

EXPERIMENTAL OBSERVATIONS

The fact that longitudinal growth of bones takes place only at their ends was first demonstrated by Hales[14] in 1727. This worker drilled two holes, one-half an inch apart, in the shaft of the tibia of a growing chicken. Observations made two months later showed that the two holes remained the same distance apart, although the entire bone had increased one inch in length. Similar experiments with modifications and improvements in technique were performed later by Duhamel[10], Hunter[23], Ollier[28], Hass[20], Gatewood and Mullen[13], and Bisgard[4]. In other experiments Ollier excised the epiphyseal cartilages of the long bones of young dogs, with resultant cessation of growth. Also, Bidder[2] inserted needles into the epiphyseal plates, following which the injured ends of the bone showed a decreased rate of growth. Similar but more detailed experiments were performed by Hass.[19] Basing his work upon these fundamental findings, Phemister[31] devised a new operation for fusion of the epiphyseal cartilage on one or on both sides of the bone.

Many workers have attempted by various means experimentally to stimulate epiphyseal growth and have hoped thereby to arrive at some method which might be used clinically to equalize the length of the extremities. In 1910, Meisenbach[27] reported the results of such experiments made on young rabbits. Various foreign materials—such as sterile water, fine sterile graphite pegs, staphylococcus vaccine, tincture of iodine, carbolic acid, alcohol, and formalin—were injected into the vicinity of the proximal epiphyseal cartilage of the tibiae. In each case, roentgenographic and microscopic examinations were made from three to six weeks after the injection. In most instances, no appreciable change was produced. In the cases in which formalin was injected, there was some de-

gree of widening of the bone, due to thickening of the cortex, but the total length was decreased. Harbin[15], basing his work on the clinical observation of overgrowth in cases of osteomyelitis, injected a suspension of staphylococcus aureus into the region of the distal epiphyseal cartilage plate of the femur of a puppy. His results showed noticeable shortening of the limb. Similar experiments were made upon guinea pigs by Bohlman[6], in 1929, who used foreign materials—such as iron, copper, lead, wood, bone, ivory, camphor, thymol, and asphalt—in the form of small pegs or powders. The materials were inserted through drill holes directly into, immediately proximal to, or distal to the distal epiphyseal cartilage plate of the femur. Observations made at the end of three months failed to show lengthening in any of the cases; on the contrary, marked shortening often resulted.

There are three chief sources of blood supply to each bone: (1) the nutrient artery, (2) the periosteal blood supply, and (3) the epiphyseal blood supply.[18, 24, 39] Disturbance of one or more of these sources of supply is undoubtedly a factor which alters the rate of growth of the epiphyses. Certain of the experimental studies along this line are of decided significance. Ollier[28] ligated the nutrient artery of a growing bone and found no apparent change in growth. Hass[18] produced various vascular changes in the bones of the feet of young dogs. Ligation of all of the large vessels of the dorsum of the foot, as well as direct destruction of the nutrient arteries to the metatarsal bones, did not affect the longitudinal growth. However, remarkable shortening resulted when he cut off the blood supply to the epiphyseal region by stripping the soft tissue from the distal end of the bone. He concluded that the maintenance of the normal longitudinal growth of bone is dependent upon a sufficient blood supply to the epiphyseal region. Pearse and Morton[29, 30] observed that venous stasis, produced by ligation of the large veins of the hind limbs of dogs, hastened the repair of artificially produced fractures of the fibula. Ligation of the main arteries, however, produced no effect because of the rapid formation of collateral circulation. It has been shown both in animals and in clinical experiments that lumbar sympathectomy produces a prolonged arterial hyperaemia of the lower limb on the operated side. Harris and McDonald[16, 17] reported their results after this operation in cases of limbs shortened by infantile paralysis. In twenty of their twenty-nine cases in which the sympathetic effect was maintained, the growth of the extremity was increased. However, Cannon[8], Bacq[1], Bisgard[3], and others did not find any change in the longitudinal growth of the limbs of unilaterally sympathectomized animals.

In 1933, Ferguson[11] described a procedure for stimulation of the longitudinal growth of bone. He curetted the marrow through small drill holes which were made midway between the middle of the shaft and the epiphyseal line. Observations upon seven bones operated on in four cases showed a gain in length of from one-eighth to one-sixth of an inch after from three to five months.

TABLE I

MEASUREMENTS OF LONGITUDINAL GROWTH OF TIBIAE AFTER INSERTION OF FOREIGN MATERIAL INTO DRILL HOLE IN BONE IMMEDIATELY DISTAL TO THE PROXIMAL EPIPHYSEAL CARTILAGE PLATE

Materials Inserted	Rabbit No.	Length of Tibiae Before Operation		Time from Operation to Autopsy (*Months*)	Length of Tibiae at Autopsy		Length of Operated Tibiae Compared with Control Tibiae	
		Left (*Millimeters*)	Right (*Millimeters*)		Left—Control (*Millimeters*)	Right—Operated (*Millimeters*)	Shortening (*Millimeters*)	Lengthening (*Millimeters*)
None	1	67.5	67.5	3	88.5	88.5		
	2	73.0	73.5	3	95.5	96.0		
Cotton	3	50.5	51.0	1	69.0	69.0	0.5	
Gauze	4	65.5	66.0	3	92.0	92.0	0.5	
	5	69.0	68.0	3	94.0	93.5		0.5
	6	70.0	70.0	3	93.5	93.5		
Paper	7	57.0	57.5	3	96.0	96.0	0.5	
Wood	8	72.5	73.0	3	91.0	91.0	0.5	
	9	72.0	72.0	3	94.0	94.5		0.5
Iron Shot	10	74.0	74.5	3	95.0	94.5	1.0	
	11	81.0	81.0	1.5	91.0	91.0		
	12	68.5	68.5	1.5	82.5	82.5		

The influences of active function of the muscles (stress and strain) upon the growth of bone was well shown by Howell[22], who severed the right brachial plexus of young dogs and observed the subsequent growth. The bones on the operated side were found noticeably shorter and considerably thinner than those on the control side.

In the experiments reported in this article, we have repeated, with minor modifications, the work of Meisenbach, Pearse, Ferguson, and others (Groups I, II, and III); also, we have used other procedures which are for the most part original (Group IV). The results of our experiments have been sufficiently encouraging to warrant a report.

METHOD OF EXPERIMENT

The experiments were performed upon fifty-two young rabbits, aged from five to eight weeks and weighing from 600 to 800 grams. In each case, the right tibia or the right femur and tibia were operated upon, and the corresponding bones of the left side were employed for control purposes. Ether anaesthesia was used. The right leg was shaved and the skin was prepared with iodine and alcohol. After operation, the wound was closed in layers with silk sutures and sealed with collodion. (The wounds healed *per primum* in all animals within a period of ten days.) Roentgenograms of both legs, at a uniform target distance of sixty-five centimeters, were taken immediately before operation and at monthly intervals following operation until the time of autopsy. Autopsies were performed at periods varying from two weeks to six months after operation. Longitudinal measurements of the bones were taken from the roentgenograms and also from the autopsy specimens. Tables I, II, III, and IV show the measurements of the bones of the legs operated upon, also those of the untouched legs. The experiments were divided into four groups as follows:

I. Insertion of Foreign Material into a Drill Hole Placed Immediately Distal to the Proximal Epiphyseal Cartilage of the Tibia

An incision, about one centimeter in length, was made on the anteromedial aspect of the upper end of the right tibia. Next, a small incision was made through the periosteum, from two to three millimeters distal to the epiphyseal line. Through this incision a small hole was drilled, tilting proximally, so that the inner end of the drill just reached the epiphyseal cartilage plate without boring into it. In two rabbits (Nos. 1 and 2), in order to estimate the effect of drilling alone, the wound was closed without any further procedure. In each of the remaining ten rabbits (Nos. 3 to 12 inclusive), a small piece of foreign material was introduced into the depths of the drill hole, following which the periosteum and soft tissues were closed in the usual manner.

As shown in Table I, various foreign materials—cotton, gauze, paper, wood, and iron shot—were used. Considering a difference in length of five-tenths of a millimeter to be within the range of normal variation, the

results showed no appreciable difference in length of the bone operated upon. These findings differ from those of Meisenbach[27] and Bohlman[6], who observed shortening after a similar procedure.

II. Indirect Interference of Circulation of Bone

In this series of experiments, performed upon twelve rabbits (Nos. 13 to 24 inclusive), various circulatory disturbances of the right posterior extremity were produced by the following methods: (1) ligation of the femoral artery; (2) ligation of the femoral vein; (3) stripping of the overlying soft tissues and application of a double, heavy silk ligature around the upper epiphyseal cartilage plate; and (4) stripping of all the soft tissues from the periosteum along the entire length of the shaft of the tibia, not including the epiphyseal ends. This last procedure interrupted the nutrient artery and also all other vessels connecting the covering of the bone with the surrounding tissues.

As shown in Table II, there was no appreciable change in the longitudinal growth after any of these experiments. The alteration of the blood supply which followed ligation of the femoral artery or vein was very transient, therefore the growth of the bone was not affected to any significant extent. The silk ligatures which were applied around the epiphyseal cartilage plate were found later, at autopsy, embedded in the periosteum of the metaphysis a short distance from the epiphyseal plate. The finding that destruction of the nutrient artery and the extraperiosteal blood supply caused no change in the longitudinal growth of bone agrees with the observations of Ollier[28] and Hass[18].

III. Ferguson's Operation—Curettage of Bone Marrow.

Ferguson's method[11] of stimulating the longitudinal growth of bone was performed on six rabbits. The bone marrow of the right tibia was curetted through a drill hole made midway between the middle of the shaft and the epiphyseal line. In four of the six rabbits (Nos. 25, 26, 27, 28), the marrow was curetted only through a drill hole made in the upper portion of the tibia, while in the other two rabbits (Nos. 29, 30), the marrow was also curetted through a second hole in the lower portion of the shaft of the bone. As listed in Table III, our observations at the end of from three to six months failed to show significant changes in the length of the operated bones. These findings differ from those noted by Ferguson in his clinical experiments upon patients.

IV. Stripping of the Periosteum

Twenty-two rabbits were used in this series of experiments. The right tibia alone was operated upon in eighteen animals (Nos. 31 to 48 inclusive), and both the right femur and tibia were operated upon in four animals (Nos. 49 to 52 inclusive). The periosteum of the tibia was exposed through a longitudinal incision on the anteromedial aspect of the bone, and that of the femur was exposed through a lateral incision. The

TABLE II

MEASUREMENTS OF TIBIAE AFTER INDIRECT INTERFERENCE WITH CIRCULATION OF BONE

Type of Operation	Rabbit No.	Length of Tibiae Before Operation		Time from Operation to Autopsy	Length of Tibiae at Autopsy		Length of Operated Tibiae as Compared with Control Tibiae	
		Left (*Millimeters*)	Right (*Millimeters*)		Left—Control (*Millimeters*)	Right—Operated (*Millimeters*)	Shortening (*Millimeters*)	Lengthening (*Millimeters*)
Ligation of right femoral artery	13	70.5	71.0	6 months	92.0	91.5	0.1	
	14	61.0	61.0	28 days	73.5	73.0	0.5	
	15	67.5	67.5	24 days	75.5	75.5		
Ligation of right femoral vein	16	70.0	69.0	6 months	101.5	101.5		1.0
	17	68.0	67.5	6 months	99.0	99.0		0.5
	18	70.0	70.5	6 months	94.0	94.0	0.5	
	19	58.5	58.0	21 days	64.0	64.0		0.5
Silk ligature around upper epiphyseal plate of tibia	20	73.0	73.5	3 months	83.5	84.0		
	21	85.0	85.0	3 months	89.0	89.0		
Stripping of muscles of right leg extraperiosteally	22	71.0	71.0	3 months	100.0	100.0		
	23	83.0	83.5	3 months	96.0	96.0	0.5	
	24	59.5	59.5	3 months	97.0	97.0		

TABLE III

MEASUREMENTS OF TIBIAE AFTER FERGUSON'S OPERATION (CURETTAGE OF BONE MARROW)

Type of Operation	Rabbit No.	Length of Tibiae Before Operation		Time from Operation to Autopsy (*Months*)	Length of Tibiae at Autopsy		Length of Operated Tibiae as Compared with Control Tibiae	
		Left (*Millimeters*)	Right (*Millimeters*)		Left—Control (*Millimeters*)	Right—Operated (*Millimeters*)	Shortening (*Millimeters*)	Lengthening (*Millimeters*)
Curettage of bone marrow	25	71.5	71.5	3	93.5	94.0		0.5
	26	76.5	76.0	3	90.0	90.0		0.5
	27	65.0	64.5	6	95.0	95.0		0.5
	28	69.5	69.5	6	97.5	97.5		
	29	68.5	68.5	3	94.0	94.5		0.5
	30	67.0	67.0	6	95.0	95.5		0.5

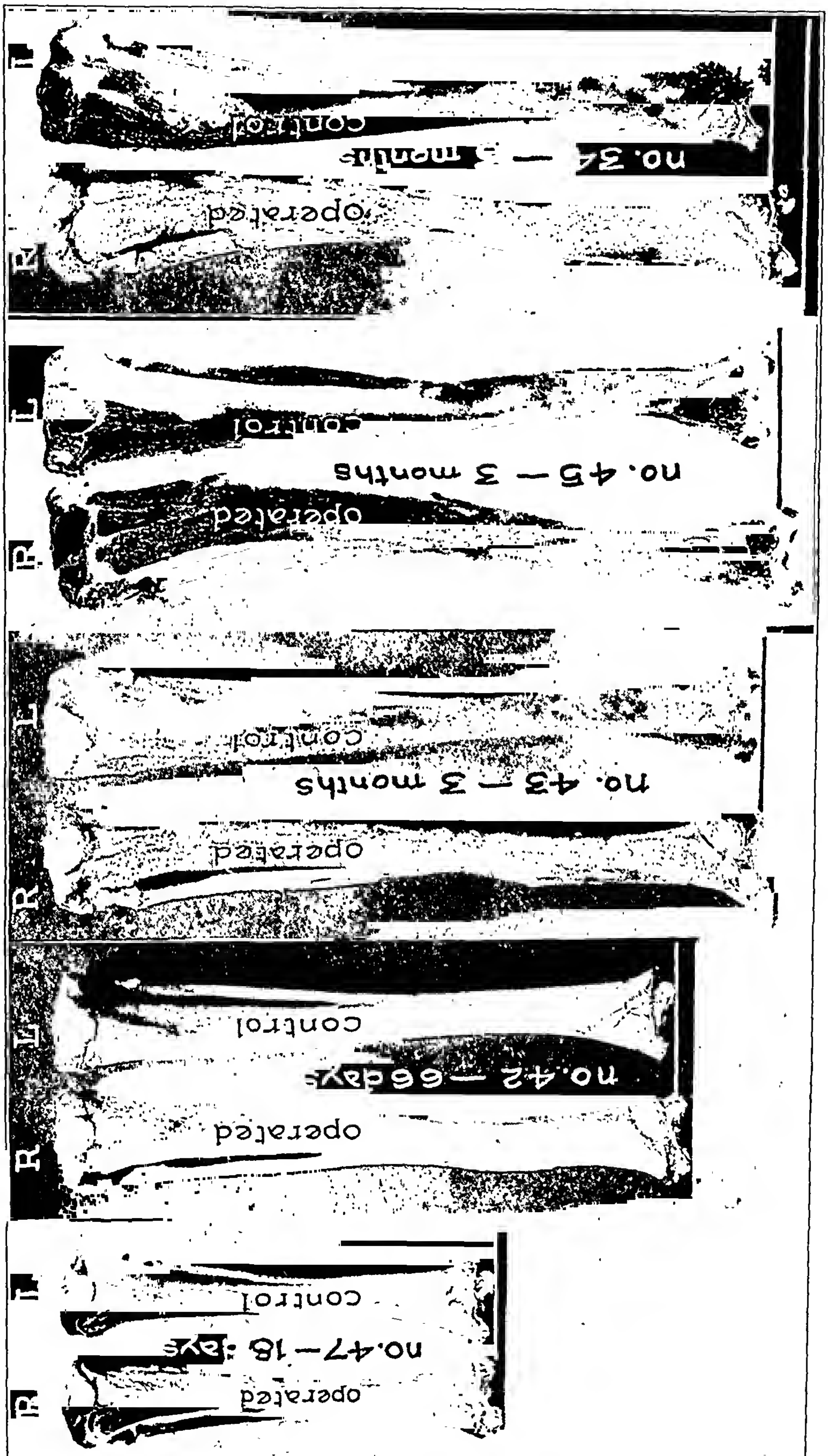

FIG. 1

Autopsy specimens following stripping of all or various portions of the shaft of the right tibia. (See Table IV.) Note the actual amount of longitudinal overgrowth of the right (operated) tibiae.

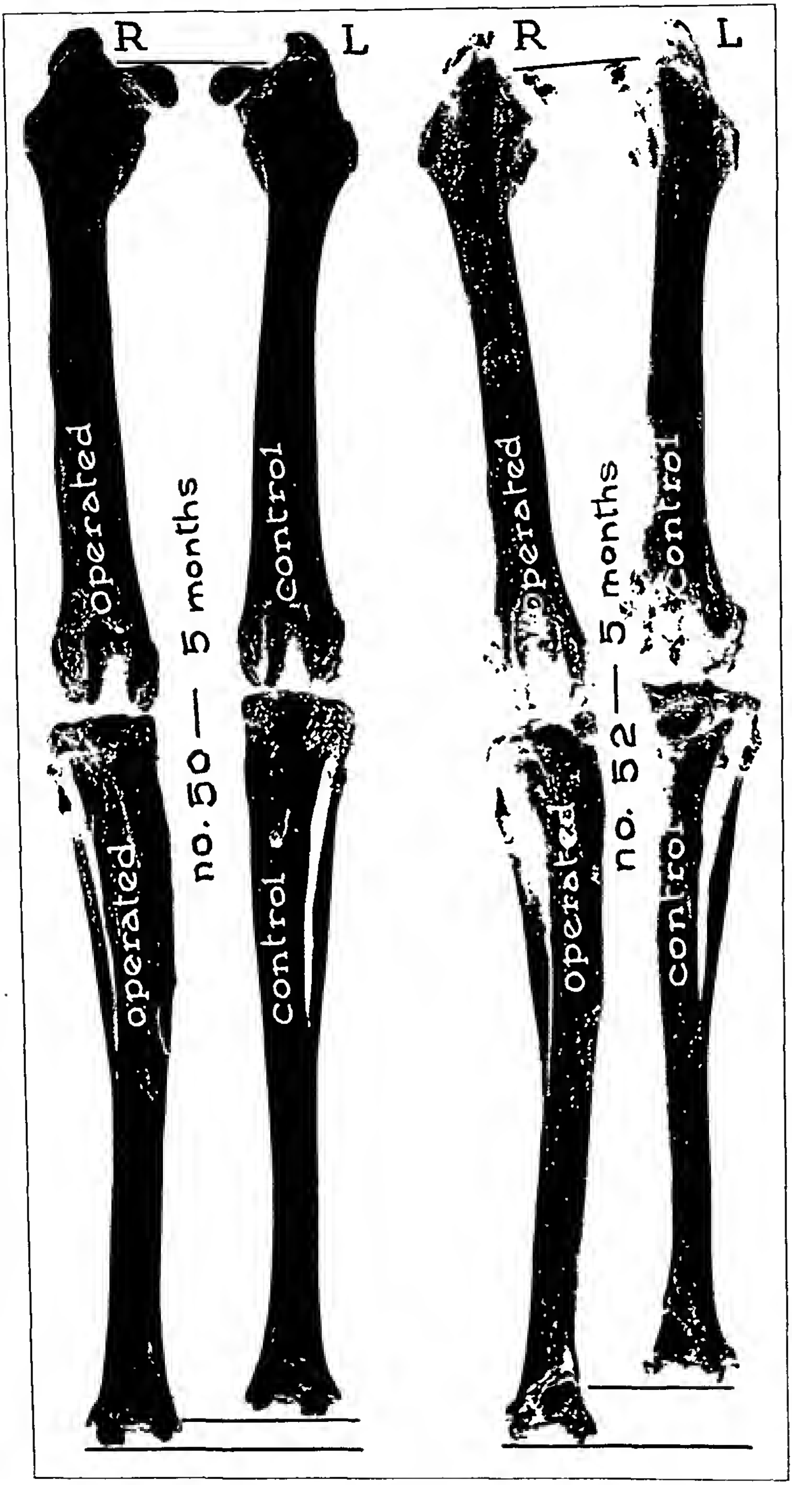

FIG. 2

Autopsy specimens of bones following stripping of periosteum of the lower half of the shaft of the right femur and upper half of the shaft of the right tibia. Note the longitudinal overgrowth of the bones on the right (operated) side.

TABLE IV

MEASUREMENTS OF BONES AFTER STRIPPING OF THE PERIOSTEUM FROM THE SHAFT OF THE RIGHT TIBIA AND THE RIGHT FEMUR

Type of Operation	Rabbit No.	Bone Operated Upon	Length of Bone Before Operation		Time from Operation to Autopsy	Length of Bone at Autopsy		Length of Operated Bone as Compared with Control Bone	
			Left (*Millimeters*)	Right (*Millimeters*)		Left—Control (*Millimeters*)	Right—Operated (*Millimeters*)	Shortening (*Millimeters*)	Lengthening (*Millimeters*)
Stripping of entire shaft of tibia	31	Tibia	59.0	58.5	20 days	63.5	66.0		3.0
	32	Tibia	66.0	65.0	23 days	73.0	74.5		2.5
	33	Tibia	74.5	74.5	1 month	87.0	90.5		3.5
	34	Tibia	67.0	67.0	3 months	95.5	100.0		4.5
	35	Tibia	61.5	61.0	3 months	96.0	98.0		2.5
	36	Tibia	57.5	57.5	5 months	95.5	96.0		0.5
	37	Tibia	56.0	56.0	5 months	92.0	93.5		1.5
	38	Tibia	54.0	53.5	5 months	92.0	95.5		4.0
	39	Tibia	52.5	52.0	5 months	92.0	96.0		4.5
	40	Tibia	53.0	53.0	5 months	93.5	97.0		3.5
Stripping of lower half of shaft of tibia	41	Tibia	68.5	69.0	21 days	73.0	75.5		2.0
	42	Tibia	60.5	60.0	66 days	82.0	85.5		4.0
	43	Tibia	64.0	64.0	3 months	93.5	96.0		2.5
Stripping of upper half of shaft of tibia	44	Tibia	63.0	63.0	3 months	92.0	95.0		3.0
	45	Tibia	63.0	62.0	3 months	95.0	100.0		6.0
Stripping of only the anterior surface of tibia	46	Tibia	58.0	57.0	19 days	62.0	63.0		2.0
	47	Tibia	58.0	58.0	18 days	57.5	59.0		1.5
	48	Tibia	63.0	63.0	15 days	65.0	65.0		
Stripping of periosteum of lower half of shaft of femur and upper half of tibia	49	Femur	41.5	42.0	5 months	82.5	84.5		1.5
		Tibia	49.5	50.0		93.0	95.0		1.5
	50	Femur	44.0	44.0	5 months	82.5	85.0		2.5
		Tibia	55.5	55.5		95.5	98.0		2.5
	51	Femur	49.0	50.0	5 months	81.5	83.0		0.5
		Tibia	59.0	59.0		93.0	93.0		
	52	Femur	54.5	55.0	5 months	82.5	85.5		2.5
		Tibia	60.0	60.0		92.0	97.0		5.0

periosteum was incised along the long axis of the bone and was stripped from all or various portions of the shaft of the bone with a curved blunt elevator. Care was taken not to injure the epiphyseal cartilage or the large blood vessels in the vicinity. Profuse bleeding was not encountered in any instance. The periosteum was replaced and sutured together with fine silk sutures after the desired amount of stripping had been accomplished. The wound was closed in the usual manner. As shown in Table IV, the animals were further divided into five groups, according to the extent of the stripping of the periosteum: (1) stripping of the periosteum from the entire circumference of the whole shaft of the tibia; (2) stripping of the periosteum from the entire circumference of the lower half of the shaft of the tibia; (3) stripping of the periosteum from the entire circumference of the upper half of the tibia; (4) stripping of the periosteum from only the anterior surface of the shaft of the tibia, leaving the nutrient artery intact; and (5) stripping of the periosteum from the entire circumference of the lower half of the shaft of the femur and the upper half of the tibia.

Table IV shows the measurements of the length of the bones after the preceding experiments. Figures 1 and 2 illustrate examples of the results obtained. Definite longitudinal overgrowth of the operated bone was observed in all instances except in the tibiae of rabbits Nos. 36, 48, and 51. The bones operated upon were seen to be slightly thicker and rougher than those of the control side, but, in spite of this, the periosteum was not particularly adherent.

The operation was repeated in rabbit No. 38 at the end of one month after the first operation, in rabbits Nos. 39 and 40 at the end of two months, and in rabbits Nos. 51 and 52 at the end of three months. Contrary to our expectations, there was no additional stimulation of the length growth which might be attributed to the second or repeated stripping procedure.

SUMMARY

In these experiments various surgical procedures were employed, with the hope of finding a method for stimulation of the longitudinal growth of bone. The first three groups of experiments (a repetition with minor modifications of the procedures of Meisenbach, Pearse, Ferguson, and others) failed to produce significant increase in the length growth.

By chance, in several animals, we observed that stimulation of the length growth was produced by the simple procedure of loosening or stripping the periosteum from the shaft of the bone. Consequently, this operation was repeated on twenty-two animals, with quite uniform and significant results, as shown in Table IV. With but three exceptions out of twenty-two rabbits, the operated leg showed definite lengthening when compared with the normal leg on the opposite side. Although the amount appeared to be small, it actually represented an increase of from 5 to 15 per cent. over the normal growth of the bone during that period of

time. Observations of the monthly roentgenograms showed that the most active stimulation of length growth of the bones took place during the first three months following the operation.

We are unable to give a definite explanation of the factors which, after the periosteum had been stripped, produced this stimulation of the longitudinal growth.

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STUDIES OF LONGITUDINAL GROWTH OF LONG BONES*

I. The Influence of Trauma to the Diaphysis

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Opinions are frequently expressed and evidence is occasionally offered to support the theories which are intended to explain the phenomena of bone growth. The exact nature of the physiological processes which regulate the rate and extent of long-bone growth are still mysteries. That certain factors, such as disease, trauma, or glandular dysfunction, may alter the rate and extent of bone growth is well known. Investigators do not agree in their attempts to explain: (1) why overgrowth of a long bone of a child occasionally occurs after fracture of the shaft; (2) why the epiphyses fuse to the shaft with complete cessation of longitudinal growth shortly after puberty; (3) what insults to the bones will consistently stimulate, retard, or arrest longitudinal growth; (4) what deformities may be predicted, following insult to the growing epiphyses; (5) how the epiphyses, themselves, grow; (6) through what biological mechanism acute or chronic systemic infections may alter the longitudinal growth of bone; (7) the relation between delayed puberty and delayed closure of epiphyseal lines of long bones; (8) the effect on rate or extent of longitudinal growth of bone or interruption of blood supply to the shaft, the metaphysis, or the epiphysis; (9) whether it is possible for the epiphysis, once destroyed, to regenerate and to function as a growth center; (10) why all long bones are preformed in cartilage and only a few bones of the head and face are formed in membrane.

Studies have been made and are being made in an attempt to throw some light upon these problems. This presentation is the first of a series of studies through which the writer and his associates hope to be able to add some information which will enable us to understand better the physiology of bone growth.

With the exception of the clavicle, all of the long bones composing the human skeleton are preformed in cartilage. They are preceded by masses of mesodermal cells which grow and differentiate into cartilaginous models of the subsequent osseous segments. By the end of the second month of intra-uterine life, the developing embryonic cartilage maps out the divisions of the skeleton. These segments, early in intra-uterine life, are required to support and to maintain the form for the soft-tissue structures which envelop them. Thus, they are subjected to forces of stress and strain, exerted by the maternal tissues and later by the muscles and

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ligaments, which create functional demands for greater skeletal support. The cartilage phase in the formation of most of the bones may be a response to this demand placed upon the embryonic skeleton by the stresses and strains to which the forming extremities and spine are subjected during the interval preceding the deposition of mineral salts and transformation into bone.

Experimental evidence presented by Hales, Hunter, Duhamel, Ollier, Wegner, Humphry, Payton, von Kölliker, Haas, Gatewood and Mullen, J. D. Bisgard, and M. E. Bisgard indicates that all increase in length of the diaphyses of long bones, both prenatal and postnatal, occurs through enchondral growth by the multiplication of the cartilage cells of the juxta-epiphyseal region, on the shaft side of the epiphyseal-cartilage plate. As an individual approaches maturity, the epiphyseal cartilage becomes thinner, and finally the epiphysis fuses to the shaft, with subsequent cessation of all longitudinal growth. The Bisgards state, and Siegling has recently demonstrated, that the epiphysis grows in length from the articular cartilage and none of the longitudinal diameter of the epiphysis results from accretion of cartilage or bone from the epiphyseal side of the growth cartilage. The proportion of longitudinal growth from the two ends of a long bone is unequal, with the disproportion greater for growth occurring after birth.

The Bisgards confirmed the work of Digby and concluded that his measurements for the percentage of growth from each end of human long bones are accurate. These figures for the percentage of growth have been corroborated by the measurements of growth of human long bones from roentgenographically demonstrated transverse growth-arrest lines which Harris has shown may result from illness, malnutrition, trauma, or the feeding of phosphorus and other chemical poisons.

ATTEMPT TO STIMULATE OVERGROWTH OF BONE BY TRAUMA TO THE SHAFT

Ollier first noted that irritation of the shaft of a bone could cause increase in the rate of growth and that it might produce overgrowth of as much as one-fifteenth of the total length of the bone. Kishikawa recently reported a study of the effect of various irritants upon the longitudinal growth of the long bones. He found that constricting the limbs, preventing free venous flow, or ligation of the femoral veins caused some growth stimulation, so that, after eight weeks, on the side of operation there was an increase in longitudinal growth of the limb of 1.77 per cent. over that on the control side. Following an injection of oil of turpentine into the bone marrow at the distal end of the femur or into the knee joint in young rabbits, there was an increased growth on the side so treated of approximately 1 per cent. after six weeks and of 5 per cent. after sixteen weeks, as compared with the non-traumatized leg.

In 1933, Ferguson reported that the rate of longitudinal bone growth could be increased by direct trauma to the bone. He propounded the theory that the increased rate of bone growth that frequently occurs

following osteotomy or fracture of a long bone in a child results from interruption of the medullary blood supply to the metaphysis without interruption of the periosteal blood supply to the end of the shaft. He devised and performed an operation in which he drilled into the shaft of long bones "half-way from the epiphyseal line or lines to the middle of the bone", inserted a knife or curette, and disrupted the continuity of the medullary substance. He performed this operation in sixteen cases in which there was a short leg. In four cases in which such an operation was performed, seven bones were examined from three to five months later. He reported a gain in length of from one-sixteenth to one-eighth of an inch. Protocols were not given and the article does not state the cause or causes of the shortening.

Lambert has used Ferguson's methods of attempting to stimulate longitudinal bone growth eighteen times on patients, eight times on rabbits, and three times on dogs. He states: "While it has not been successful in increasing long-bone growth in every case (most notable of the failures were in a congenital fracture of the femur and in a spina bifida) most of them have shown some response." One patient showed a gain of three and four-tenths centimeters over a period of years following the operation. Whether or not other factors played a part in this was not discussed. Since neither Ferguson nor Lambert supplied protocols of their cases, the causes of shortening are not known. Orthopaedic surgeons are all familiar with the fact that during the pre-adolescent period of rapid growth a leg that is short because of paralysis from poliomyelitis often makes a definite gain in length as compared with the more normal

TABLE I

GROWTH STIMULATION FROM TRAUMA † IN RABBITS, AGED THREE WEEKS

Rabbit No.	No. of Days after Operation	Length of Tibia *		Length of Femur *		Difference in Length	
		Left (*Centimeters*)	Right (*Centimeters*)	Left (*Centimeters*)	Right (*Centimeters*)	Tibia (*Centimeters*)	Femur (*Centimeters*)
12.	48	7.2	7.2	6.8	6.7	0.0	0.1
13.**	48	7.2	7.1	6.0	6.5	0.1	−0.5
14.	48	7.6	7.6	6.8	6.8	0.0	0.0
15.	67	7.9	7.9	7.1	7.1	0.0	0.0
16.	73			7.1	7.1	0.0	0.0
17.	77			7.7	7.7	0.0	0.0

† On December 18, 1937, three holes were drilled through the left femur, completely disrupting the continuity of the medullary substance. There was no consistent growth change.

* Measurements from top of femoral head to tip of medial condyle and from tip of tibial spine to tip of medial malleolus.

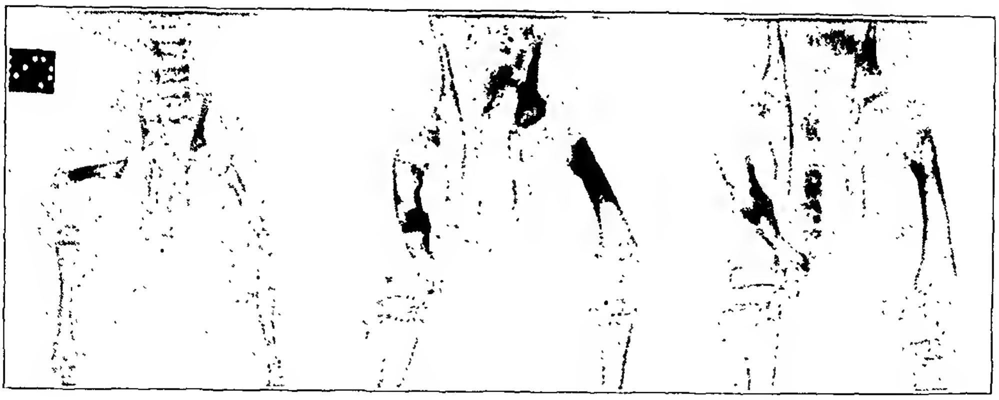
** Femur fractured.

leg. This increased rate of growth is probably associated with improved muscle function. Clinical results which do not take this fact into consideration must be accepted with reservations. The theory which Ferguson has propounded to explain overgrowth that occurs following fracture or osteotomy of the long bones of a child fails to take into consideration the factor of hyperaemia in the traumatized limb.

Experiment I

An experiment was devised in which an attempt was made to traumatize the bone with minimal injury to the soft tissues. Rabbits, aged three weeks, were used. Without incision to expose the femur, three drill holes, the diameters of which were approximately that of the medullary canal of the femur, were made through both lateral and medial cortices, near the upper and lower metaphyses and in the mid-third of the shaft. The diameter of the drill was thus sufficient to remove approximately one-half of the cortical circumference and to disrupt effectively the medullary blood supply. The femur was so much weakened as a result of this procedure that in several instances a fracture occurred either at the time of operation or shortly afterward. Six rabbits so treated survived from forty-eight to seventy-seven days after operation. Roentgenograms were taken at intervals, but no evidence of growth stimulation was observed. The specimen removed at necropsy included both femora and both tibiae. These were measured accurately by means of calipers. (See Table I.) The femur of rabbit No. 12, which had been drilled, was found to be one millimeter longer than that of the control side. In rabbit No. 13 a fracture had occurred with slight displacement, which no doubt resulted in the shortening of five millimeters noted. Four rabbits, which survived from forty-eight to seventy-seven days, showed no difference in length of either the tibiae or the femora. This experiment would seem to us to indicate that trauma which is sufficient to interrupt medullary blood supply but not great enough to cause a regional hyperaemia during the period of bone repair will not consistently cause growth stimulation and overgrowth.

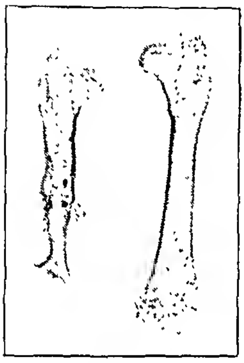
Although Speed, Broca, Truesdell, Cole, and David have described overgrowth of long bones in children following fractures, and Bisgard has demonstrated a similar overgrowth in experimental animals, the consensus of opinion of these observers has tended to coincide with that of earlier writers who believed that all longitudinal bone growth occurred from the epiphyses. David, Gatewood and Mullen, and Cole concluded that this growth stimulus was a compensatory phenomenon which came about as a result of shortening following fracture. The results of the studies of Bisgard and of our own observations definitely oppose this theory. Approximately the same degree of overgrowth occurs following a fracture in which union takes place without shortening, and hence it would not seem to be a compensatory mechanism. We have observed one instance



August 20, 1936
FIG. 1-A

September 8, 1936
FIG. 1-B

September 30, 1936
FIG. 1-C



November 12, 1936
(Specimen)
FIG. 1-D

Operation performed on a three-day-old rabbit on August 11, 1936. Both upper and lower metaphyseal regions of the femur were denuded and the round ligament was cut. Metal foil was placed in the medullary portion of the shaft. Note the formation of spindle-shaped new bone with progressive separation of the two pieces of metal foil, suggesting interstitial bone growth. Growth from the distal femoral epiphysis was arrested after three weeks.

of what appears to be interstitial bone growth. In an experiment which was performed to determine the effect upon bone growth of interrupting the circulation to the metaphyseal and epiphyseal regions, the lower end of the femur was completely denuded, the round ligament was cut, and the proximal metaphysis was stripped. This femur was then left with the blood vessels entering only the diaphysis. In order that a fixed point might be maintained from which to measure the growth from the two ends of the femur following such extensive trauma, a small amount of metal foil was inserted into the diaphysis. In one of the rabbits so treated two pieces of metal foil were used. This foil, together with the operative trauma, resulted in irritation and overproduction of bone, producing a spindlelike enlargement of the shaft. In subsequent roentgenographic observations over a period of three months (Figs. 1-A, 1-B, 1-C, and 1-D), the two pieces of metal foil became separated until they were approximately four millimeters apart. This observation indicated that either the metal foil had migrated in the medullary canal or interstitial longitudinal growth of bone had occurred at the site of irritation. This is quite contrary to the theories expressed by earlier workers, and certainly does not occur normally. Because of this observation, however, it was decided to repeat an experiment recently reported by Bisgard with regard to growth stimulation following fracture and, in particular, to determine whether or not the callus formed at the site of fracture, which contains varying amounts of cartilage, might contribute to the overgrowth of this bone.

Experiment II

Twenty-one rabbits from three litters were used for this experiment. Of ten rabbits three days old (Group A), eight femora and two tibiae were

fractured between metal markers. Of seven rabbits five days old (Group B), one femur was fractured after metal points had been placed in the shaft near the metaphyseal regions; markers were placed in a second rabbit's femur, but the bone was not fractured; four tibiae were marked with metal points and fractured between; and one tibia with metal points was not fractured. *In none of these could we demonstrate any separation of the markers*, although an abundant callus formed in connection with the healing of the fracture. In Group C four rabbits, seven weeks old, were used. An open operation was performed, and metal shot were inserted in drill holes in the cortex of the bone, the defects in the bone being such that the shot were held firmly in position. These shot were placed two centimeters apart by accurate measurements. The shaft of the tibia was then fractured between the shot. The fracture was reduced and fixed in an end-to-end position. Roentgenograms were taken, using a carefully standardized technique, at intervals of two weeks. Specimens were obtained at necropsy of two rabbits after one month and of the remaining two rabbits after seven weeks.

In rabbit No. 2, the alignment of the fractured bone was well maintained. As a result of the fracture, there was an immediate shortening of one and seven-tenths millimeters. After five weeks, this fractured tibia was found to be two millimeters longer than its mate, a total gain of

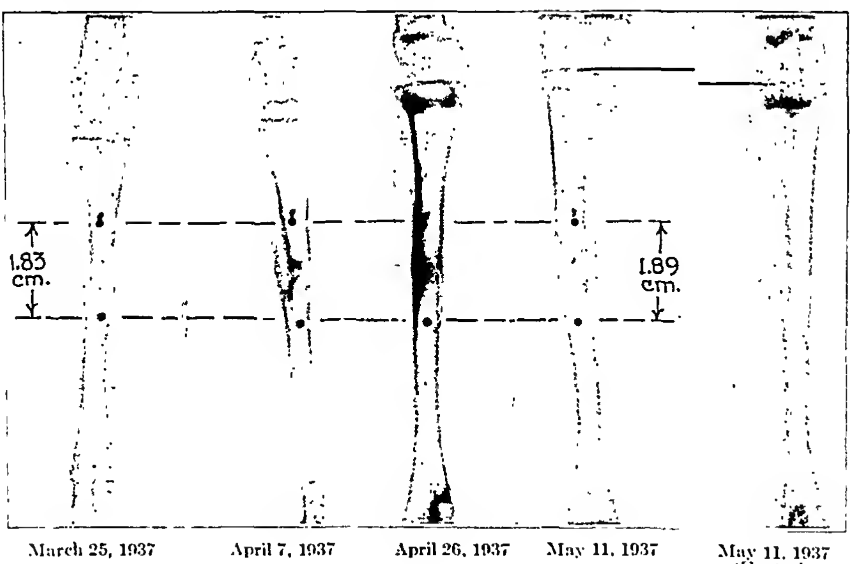


FIG. 2

Experiment II. Rabbit 2. Before the tibia was fractured, two shot, spaced two centimeters apart, were embedded in the cortex. Loss of substance or impaction of the reduced fracture resulted in immediate shortening of one and seven-tenths millimeters. Seven weeks later the distance between the two markers had increased by six-tenths of a millimeter. Since a similar separation of markers did not occur in other rabbits of the series, it would seem reasonable to assume that this was the result of slight separation of the fracture ends during the process of healing rather than of interstitial growth. Measurements made after necropsy showed that the fractured tibia was two millimeters longer than the normal control. This indicated a total epiphyseal-growth stimulation of three and one-tenth millimeters.

April 7, 1937 April 26, 1937 May 11, 1937

FIG. 3

Experiment II. Rabbit 4. No interstitial bone growth or growth from cartilage of fracture callus in the presence of overriding and angulation.

more than three millimeters (Fig. 2). During the succeeding two weeks, however, this growth stimulus seems to have been lost, and the normal tibia made a gain of five-tenths of a millimeter. Since the fracture was well united at the end of five weeks, this observation suggests that the growth stimulus only lasts until healing is complete, after which there may be a tendency for the normal and temporarily short bone to catch up. The final measurement of distance between the metal shot shows them to be approximately six-tenths of a millimeter farther apart than immediately after fracture.

In rabbit No. 4, some displacement and angulation occurred at the site of the fracture, with abundant production of callus. No longitudinal growth occurred in the diaphysis or at the site of the fracture (Fig. 3). This experiment definitely casts a doubt upon the interpretation of interstitial growth demonstrated in Figures 1-A, 1-B, 1-C, and 1-D. The results are in accord with those of Bisgard in showing that overgrowth of bone may occur following fracture without a significant decrease in length from over-riding, displacement, or the loss of a segment of the shaft of the bone. The longitudinal overgrowth of bone following fracture of the shaft occurs entirely from stimulation of the epiphyseal growth cartilage and not from the cartilage of the fracture callus of interstitial diaphyseal elongation.

STIMULATION OF OVERGROWTH FOLLOWING REMOVAL OF TIBIAL BONE GRAFT

Our studies showed that minimal trauma to the diaphysis did not cause overgrowth, while fracture or osteotomy produced stimulation of

Case No.	Name	Age at Operation (*Years*)	Time after Operation	Measurements Taken *	Operated Side (*Centimeters*)	Non-Operated Side (*Centimeters*)	Difference (*Centimeters*)	Comments
1.	R. K.	3	3 years	Growth line (1)† laid down approximately one year after operation.				
				Tibia: diaphysis	19.6	19.2	0.4	Overgrowth of 0.4 of a centimeter on operated side one year following operation, with equal growth since.
				Fibula: diaphysis	19.0	18.8	0.2	
				Tibia: proximal G. L. (1) to distal G. L. (1)	16.0	15.6	0.4	
				proximal G. L. (1) to proximal E. L.	1.9	1.9	0.0	
				distal G. L. (1) to distal E. L.	1.8	1.8	0.0	
2.	D. Y.	6	6 years	Tibia: diaphysis	29.0	29.2	−0.2	No overgrowth. Osteoperiosteal graft only was removed from this tibia.
				Fibula: diaphysis	28.0	28.2	−0.2	
				Tibia: distal G. L. (1) to distal E. L.	1.2	1.2	0.0	
				distal G. L. (2) to distal E. L.	3.7	3.7	0.0	
				distal G. L. (3) to distal E. L.	4.1	4.1	0.0	
				distal G. L. (4) to distal E. L.	6.4	6.4	0.0	
3.	R. J.	14	6 months	Tibia: diaphysis	38.8	38.7	0.1	Overgrowth of 0.1 of a centimeter in six months.
				Fibula: diaphysis	34.5	34.4	0.1	
4.	D. S.	5	6 years	Tibia: diaphysis	28.0	27.5	0.5	Overgrowth of 0.5 of a centimeter. Tibia of operated side overgrew fibula 0.4 of a centimeter. Osteoperiosteal graft.
				Fibula: diaphysis	27.3	27.2	0.1	
				Tibia: distal G. L. (1) to distal E. L.	1.1	1.1	0.0	
				distal G. L. (2) to distal E. L.	1.6	1.6	0.0	
				distal G. L. (3) to distal E. L.	2.5	2.5	0.0	
				distal G. L. (4) to distal E. L.	3.2	3.0	0.2	
				distal G. L. (5) to distal E. L.	4.7	4.4	0.3	
5.	M. S.	8	2 years	Tibia: diaphysis	25.7	25.4	0.3	Overgrowth of 0.3 of a centimeter following operation, with equal growth since. Some tendency recently to compensate.
				Fibula: diaphysis	25.5	25.5	0.0	
				Tibia: proximal G. L. (1) to proximal E. L.	1.6	1.7	−0.1	
				proximal G. L. (2) to proximal E. L.	4.7	4.6	0.1	
				distal G. L. (1) to distal E. L.	1.2	1.2	0.0	
				distal G. L. (b) to distal E. L.	2.9	2.9	0.0	
				distal G. L. (c) to distal E. L.	5.8	5.7	0.1	
6.	M. M.	5	6 months	Tibia: diaphysis	20.5	20.4	0.1	Overgrowth of 0.1 of a centimeter in six months following operation.
				Fibula: diaphysis	19.8	20.0	−0.2	
7.	S. M.	2½	6 months	Tibia: diaphysis	14.2	14.0	0.2	Overgrowth of 0.2 of a centimeter in six months following operation.
				Fibula: diaphysis	14.2	14.3	−0.1	
				Femur: distal G. L. (1) to distal E. L.	0.8	0.8	0.0	
				Tibia: proximal G. L. (1) to proximal E. L.	0.5	0.4	0.1	
				distal G. L. (1) to distal E. L.	0.5	0.4	0.1	
				proximal G. L. (1) to distal G. L. (1)	13.5	13.5	0.0	
				Fibula: proximal G. L. (1) to proximal E. L.	0.4	0.4	0.0	
8.	C. C.	8	3 years	Tibia: diaphysis	31.6	31.0	0.6	Overgrowth of 0.8 of a centimeter or more following operation. Recent more rapid overgrowth of the non-operated side.
				Fibula: diaphysis	31.3	30.7	0.6	
				Tibia: distal G. L. (2) to proximal E. L.	28.8	28.0	0.8	
				distal G. L. (1) to distal E. L.	2.4	2.6	−0.2	
				distal G. L. (2) to distal E. L.	2.8	3.0	−0.2	

longitudinal growth. This suggested that complete loss of continuity of the bones might be required to produce sufficient stimulation to cause overgrowth.

The trauma to a tibia incident to removal of a bone graft was next studied. The length of the tibiae of growing children who had been subjected to operations such as spine fusion, in which it was necessary to remove full-thickness cortical or heavy osteoperiosteal grafts from one tibia, was determined by roentgenographic measurements. Table II shows the results of measurements made on a series of eight patients. No

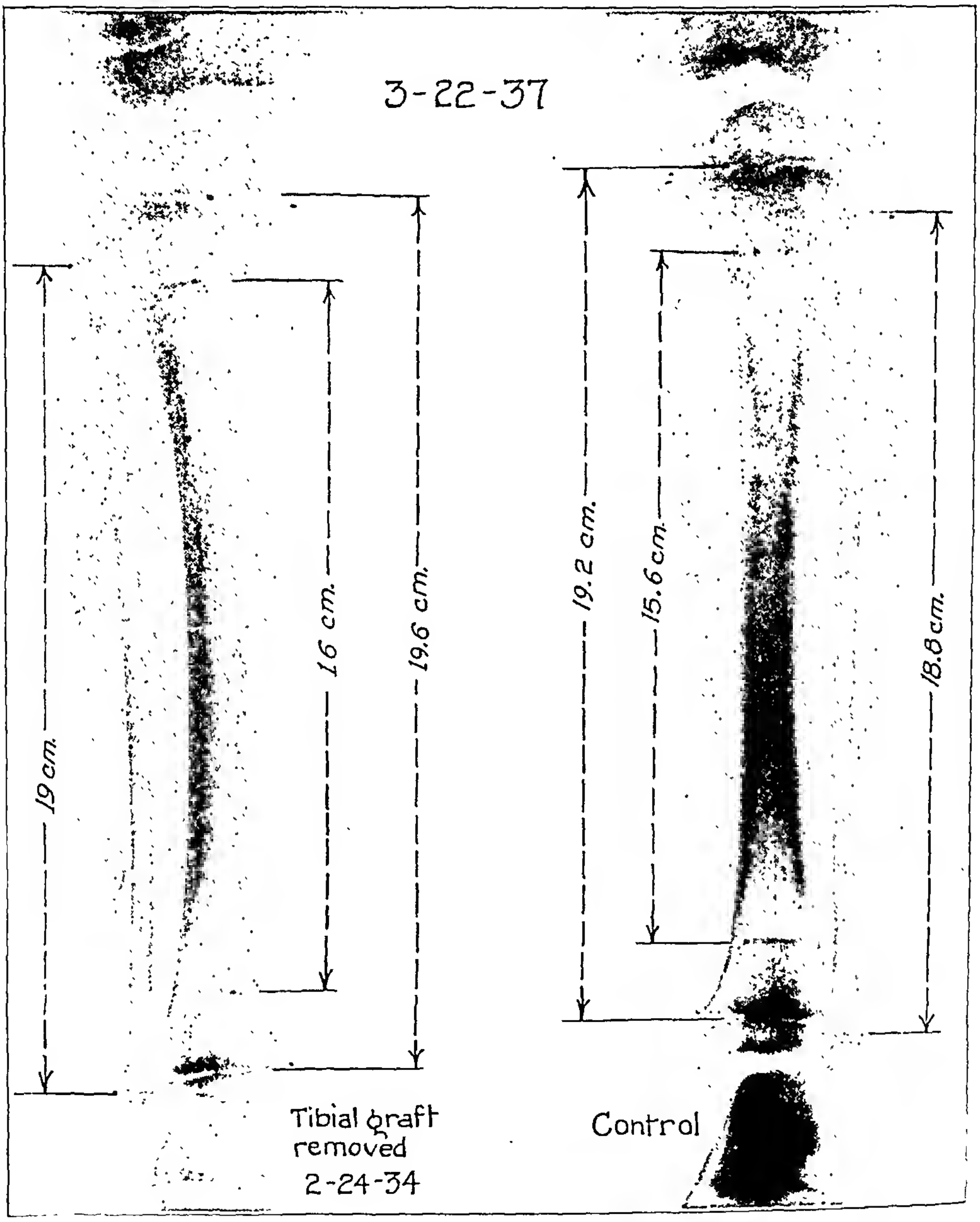


Fig. 4

Case 1 (Table II). Longitudinal overgrowth of tibia and fibula, following removal of full-thickness cortical bone graft. Increased rate of growth no longer present after one year from the time of operation, as shown by transverse growth-arrest lines.

attempt was made to compare the lengths of two tibiae in cases where there was any coexistent history of disease in the hip joint. In each instance in which the tibia had been insulted by the removal of a full-thickness cortical graft, overgrowth occurred. In only one of the patients, Case 2, was there failure of the operated limb to grow longer than the normal. In this case, only an osteoperiosteal graft had been removed.

Roentgenograms of Case 1 (Fig. 4) show that overgrowth of four-

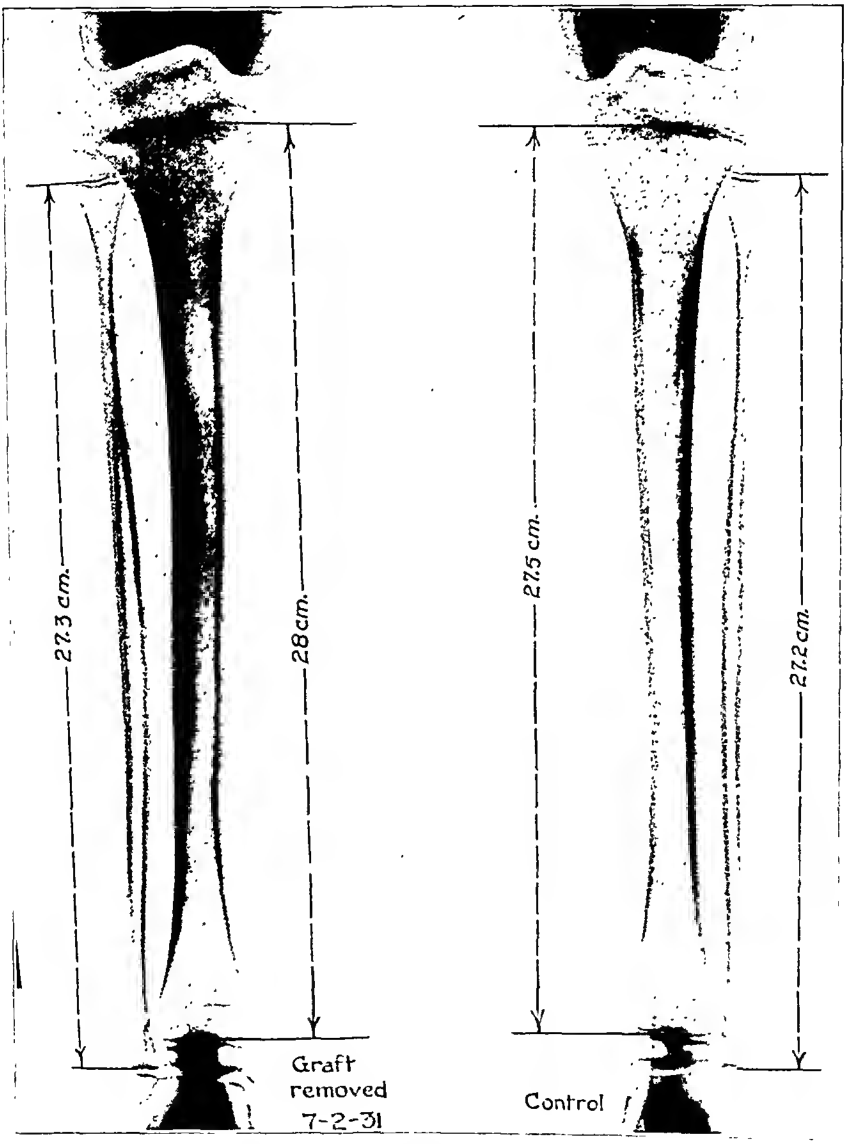
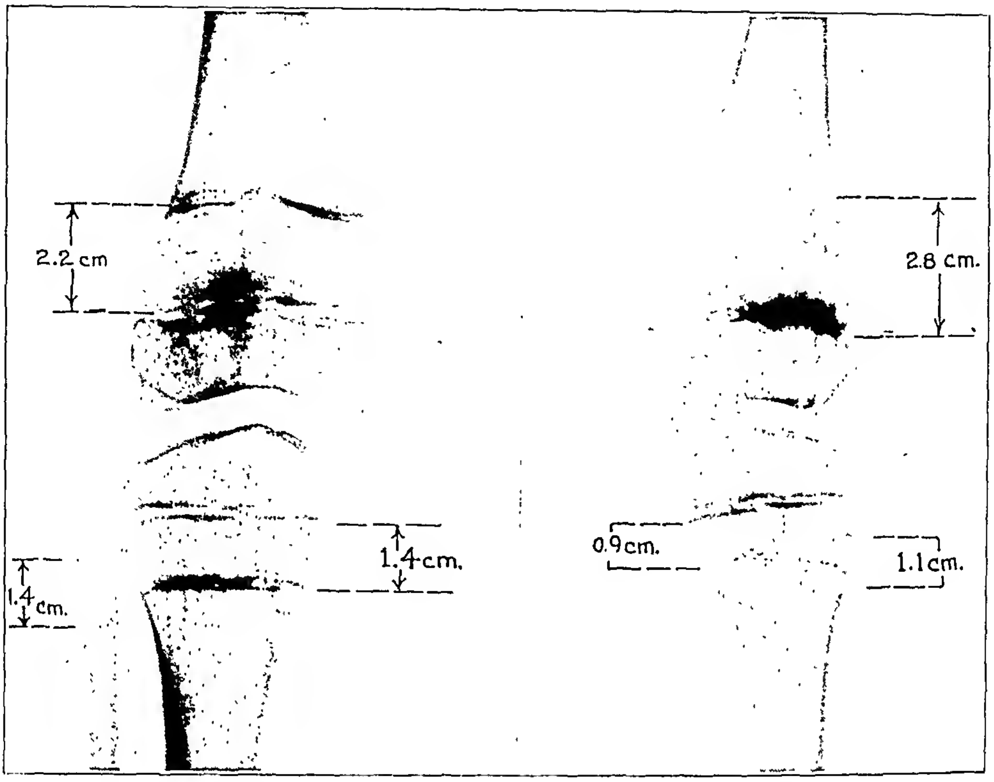


FIG. 5

Case 4 (Table II). April 11, 1937. Longitudinal overgrowth as a result of operation for removal of tibial bone graft. A difference of five-tenths of a centimeter in the tibial length is still present six years after operation.



Right
October 26, 1936

Left
October 26, 1936

Fig. 6

Growth stimulation of distal femoral epiphysis as a result of disease and operative trauma (arthrodesis of left hip, June 29, 1934, and insertion of tibial bone graft). Growth from the distal femoral epiphysis is six-tenths of a centimeter greater than that of the same epiphysis of the normal leg. Note that growth stimulus of the normal tibia is greater than that of the side of the disease. This may be due, in part, to atrophy of disuse of the tibia of the diseased leg; in part, to growth stimulation of the normal tibia as a result of removing a bone graft two years and four months earlier.

tenths of a centimeter had occurred in the tibia and of two-tenths of a centimeter in the fibula. Since the fibula was not exposed during the operation, this growth stimulus could be accounted for only by the hyperaemia which resulted from the operation or as secondary to the growth stimulus in the tibia. The growth-arrest lines shown in the roentgenograms were laid down less than a year from the time of operation as a result of an acute secondary infection. All of the increased growth was found to have occurred during this first year. The amount of longitudinal growth which occurred during the succeeding two years had been identical in the two tibiae. This is further evidence that the growth stimulus resulting from trauma to long bones lasts only until healing of the defect in the bone.

Roentgenograms of Case 4 (Fig. 5), made six years after removal of a tibial graft, show that there is still present an overgrowth of five-tenths of a centimeter in the operated tibia and of one-tenth of a centimeter in the fibula. The most marked degree of overgrowth was that of Case 8 in which overgrowth of eight-tenths of a centimeter occurred within a few

months following operation. A growth-arrest line was then laid down, following an intercurrent infection. Subsequent to this incident, the normal tibia gained two-tenths of a centimeter as compared with the operated leg. This suggests that, following growth stimulation as a result of trauma, the growth rate may lag for a time in the operated limb, permitting the normal limb, which is growing at the normal rate, to gain in relative length.

GROWTH STIMULATION FROM AMPUTATION OR EXTENSIVE TRAUMA TO PROXIMAL END OF FEMUR

Selye has demonstrated the ability of very young rats to regenerate epiphyses at the amputation end of long bones, and he concludes that such regenerative epiphyses will contribute to long-bone growth. In the rats over five weeks of age at the time of amputation this regeneration did not occur. Mullen and Gatewood demonstrated marked stimulation of epiphyseal growth in rabbits following amputation. Markers were placed in both femora at the time of amputating in the mid-thigh region. The epiphyseal growth of the remaining epiphyses of the femur of the amputated leg overgrew the control epiphyseal plates from one millimeter to nine millimeters in seven of ten rabbits. There was no evidence of any growth in the diaphyses, and a definite tendency for absorption of the end of the stump was noted. These experimental studies stimulated us to review some of our clinical cases in which traumatizing operations had been performed at the hip, to determine whether or not this produced any growth stimulation of the distal femoral epiphysis. As no markers had been placed in these femora, we had to depend upon the presence of growth-arrest lines. Figure 6 shows the distal ends of the femora of a patient with tuberculosis of the left hip, who was operated on in 1934, at the age of six years. The left hip was arthrodesed by means of partial excision and a tibial bone graft which was taken from the right tibia. This patient was given phosphorized cod-liver oil for several weeks following the operation, and heavy transverse growth-arrest lines were laid down. From the time of the laying down of these lines, which approximately coincided with the operation on the hip, there was overgrowth of six-tenths of a centimeter from the distal end of the operated left femur. This was in spite of the fact that this limb showed marked atrophy of disuse, resulting from disease in the hip over a period of nearly four years. As evidence of the fact that this over-growth did not occur because of absence of weight-bearing, the growth from the proximal end of the tibia on the side of the diseased hip is less than that on the normal side. Again, we have the possible factor of growth stimulation due to the trauma resulting from taking a tibial graft from the normal right leg, which presumably accounts in part for the overgrowth of that tibia as compared with the left. This, too, would indicate that growth stimulation as a result of trauma to one bone does not affect other bones in the same extremity to the same degree.

DISCUSSION

The consensus of opinion of investigators and of clinical observers has been that there is no length growth from the diaphysis, even when the growth rate of a long bone is increased following injury, such as may occur from trauma or disease. Our studies confirm those of Bisgard that overgrowth may occur following fracture of a long bone in the absence of any shortening from overriding of the fragments or loss of a portion of the shaft. Our experimental studies show that this increased rate of growth occurs from the epiphysis and not from the diaphysis or the cartilaginous callus which forms at the site of the fracture. In only one experimental animal was there an apparent increase in length of the diaphysis at the site of fracture and this was too small an amount to be significant. Overgrowth may occur from gross mechanical trauma to the long bone without fracture, and the amount of increased growth depends to some extent upon the degree of the trauma and the rapidity of repair of the defect in the traumatized bone. It does not depend upon interruption of the medullary blood supply. The placing of three drill holes, of the diameter of the medullary canal, through the shaft of a long bone does not afford sufficient stimulus to cause a consistent or definite increased rate of growth in that bone. The removal of a full-thickness tibial bone graft from the young child does cause sufficient growth stimulus to produce some overgrowth in the bone so insulted. This increased rate of growth does not last more than a few months, apparently continuing until repair of the defect is complete. Some overgrowth may occur in the fibula of the operated leg, but this is less than that in the tibia. Longitudinal overgrowth as a result of gross mechanical trauma to one long bone does not occur in bones of other segments of that extremity.

Studies which show growth stimulation and an increase in length of the traumatized limb over the normal, when there is no increased functional demand placed upon the extremity because of shortening, would seem to disprove the conclusion that the stimulus which occurs following fracture with overriding is compensatory in nature. Overgrowth produced by chronic inflammation in the bones of an extremity (without actual destruction of the epiphysis or of the growth-cartilage plates) can best be explained on the basis of local hyperaemia, and in all probability the growth stimulus which occurs following mechanical trauma, such as fracture or excision of bone grafts, should be explained in the same way. Further evidence of this theory may be found in the cases of marked overgrowth of an extremity associated with arteriovenous aneurysm.

CONCLUSIONS

1. Minimal trauma to the shaft or to the metaphysis of a long bone, with or without interruption of the medullary blood supply, does not produce any definite increase in rate or extent of longitudinal bone growth.
2. Gross trauma, involving a considerable portion of the shaft of a

long bone and necessitating extensive repair over a long period of time, does produce epiphyseal stimulation and longitudinal overgrowth.

3. The increased rate of growth continues only during the period of healing.

4. This growth stimulation appears to be secondary to the hyperaemia and increased vascularity of the bone and soft parts following the trauma and during the process of healing.

5. The longitudinal overgrowth which may accompany a fracture occurs regardless of whether or not there is initial shortening as a result of overriding or loss of shaft substance. This observation, together with the fact that overgrowth may also occur after gross trauma without loss of continuity of the shaft of a bone, such as excision of a full-thickness tibial bone graft, is further evidence to support the theory of local hyperaemia as the basic stimulus and that it is *not* a *compensatory phenomenon.*

6. Evidence that longitudinal bone growth may occur from the diaphysis or from the cartilage of the callus following fracture of the shaft is not well supported by the data presented.

7. Chronic localized inflammation of the diaphysis, due to an irritant foreign body, may result in marked bone proliferation with increased diameter of the shaft. There is some evidence that under these circumstances localized interstitial longitudinal growth may occur. This possibility is deserving of further investigation.

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ISCHIOPUBIC OSTEOCHONDRITIS

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Osteochondritis of the epiphysis of the ischiopubic junction was first described in 1924 by Van Neck who had observed five patients. In the same year Odelberg published his experience with four patients. He was followed in 1925 by Valtancoli and in 1926 by Wülfing, each author reporting five cases. In 1930 two more articles appeared,—one by Asplund and one by Davidson. The latest contribution is that by Torgersen who reported two cases in September 1936. As far as can be ascertained, there are no accounts of personal observations in the English literature, although King, in his excellent monograph on localized rarefying conditions of bone, gives a brief description of the condition. In view of this fact it seems well worth while to analyze briefly a series of five patients observed in the past seven years.

CASE REPORTS

Case 1. A white boy, eight years old, was brought to the hospital because of pain in the left hip and inability to walk. The pain had been present two weeks and was referred at times to the left knee. There was no history of immediately preceding injury or infection, but three months before the onset the boy had had an attack of "influenza".

The hip was held in 135 degrees of flexion with motion greatly restricted by muscle spasm. Tenderness was very pronounced over the descending ramus of the left pubis. There was questionable tenderness about the hip joint proper, but no swelling or redness. The blood count showed a leukocytosis of 21,400 with 80 per cent. polymorphonuclears. Other laboratory tests, including blood Wassermann reaction, gave no significant information. Roentgenograms showed an area of rarefaction with roughening and thickening at the junction of the descending pubic ramus and the ischium on the left side.

The tonsils were regarded as a possible focus of infection and were removed. The orthopaedic treatment consisted of recumbency on a Bradford frame with traction to the left hip. Pain and muscle spasm subsided very rapidly and, on discharge, nine weeks later, the patient had normal motion in the hip and walked without a limp. He has remained well since. Subsequent roentgenograms show complete regeneration of the ischiopubic junction.

The following report is contributed by Dr. Robert C. Robertson of Chattanooga, Tennessee.

Case 2. A white boy, seven years old, was brought to the office because of pain in the left side of the pelvis. The pain had been present for nine days and had followed a wrestling bout in which the left hip was pressed against a rock. Fever had ranged up to 103.5 degrees. There was no history of infectious disease antedating the injury.

The boy walked with a limp, the hip and knee were held slightly flexed, and great tenderness existed over the ischial tuberosity. Laboratory tests showed no abnormal findings except for a leukocytosis of 20,400 with a polymorphonuclear count of 83 per cent. Roentgenograms showed an irregular area of roughening with rarefaction at the junction of the descending pubic ramus and the ischium on the left side.

Hot, wet dressings were applied and the patient was kept in bed for six weeks. During this time he was afebrile and symptomless, and he has remained so on resuming

activity. Limitation of motion has disappeared entirely, but some palpable thickening persists about the ischial tuberosity.

CASE 3. A white girl, aged five years, was seen because of intermittent pain in the left hip, sufficient to make her limp. This had been present off and on for several weeks. There had been no injury, infectious disease, or fever.

The hip had a full range of motion with slight muscle spasm on extreme flexion and

FIG. 1-A

Case 1. Lesion of ischiopubic junction during acute stage.

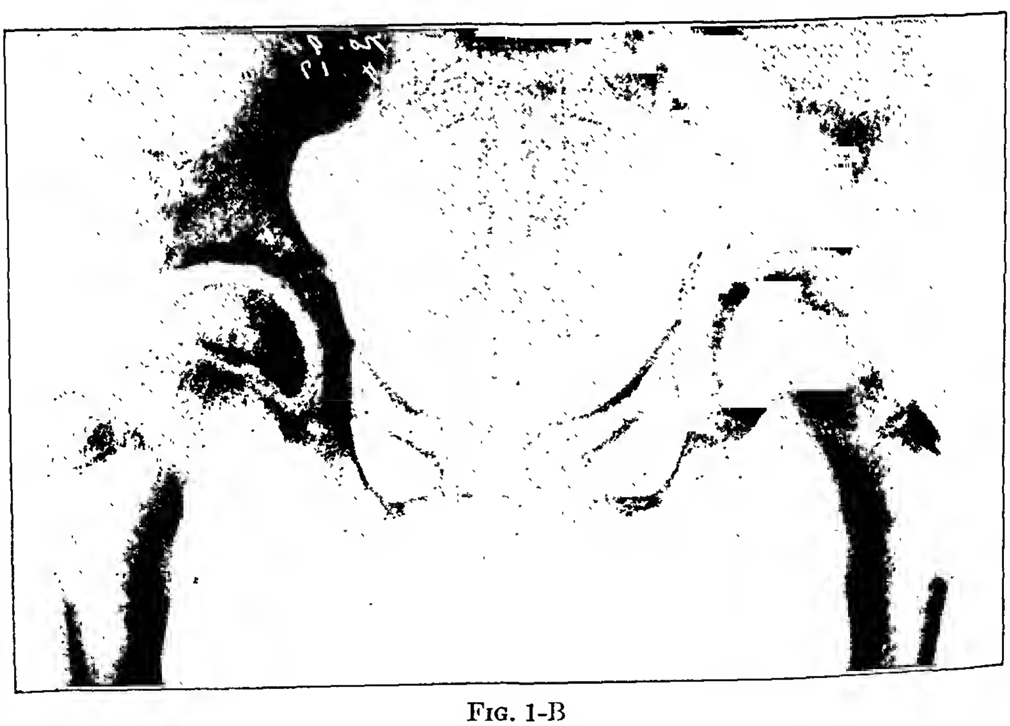

FIG. 1-B

Case 1. Healed ischiopubic junction one year later.

very definite spasm on rotation and abduction. The descending ramus of the pubis and the ischiopubic junction were tender, but the hip joint itself was not. Roentgenograms showed roughening and thickening at the junction of the ischium and the descending ramus of the pubis on the left. The patient was put to bed with traction to the left leg for four weeks and kept in bed without traction for an additional three weeks. At the end of that time all symptoms and physical signs had disappeared and a roentgenogram revealed complete fusion at the ischiopubic junction.

CASE 4. A white girl, aged seven years, came to the hospital with a complaint of

FIG. 2-A

Case 2. Lesion of ischiopubic junction during acute stage.

FIG. 2-B

Case 2. Healed ischiopubic junction three months later.

pain in the right hip and inability to walk. The pain had been present about two weeks and had followed an attack of otitis media by an interval of a few days. There was no history of injury. The family history indicated that the father had active pulmonary tuberculosis.

The hip was held in 135 degrees of flexion and 20 degrees of abduction. All motion was restricted by intense muscle spasm. The descending pubic ramus was very tender. The hip joint itself was free from tenderness, redness, or swelling. Laboratory tests revealed only a leukocytosis of 16,700 with 83 per cent. polymorphonuclears. The roentgenogram showed an area of rarefaction with thickening and irregularity at the junction of the descending ramus of the right pubis and the ischium. The same condition was present to a lesser degree on the left, but without producing any symptoms. The temperature was 102 degrees on admission, but returned to normal in three days.

FIG. 3-A

Case 3. Lesion of ischiopubic junction during acute stage.

FIG. 3-B

Case 3. Healed ischiopubic junction ten weeks later.

The tonsils were regarded as a possible focus of infection and were removed. The patient was placed on a Bradford frame with traction to the right leg for six weeks, and kept in bed an additional two weeks. She recovered a full range of painless motion at the hip and has had no recurrence. Final roentgenograms show complete fusion of the ischium and pubis.

FIG. 4-A
Case 4. Lesions of ischiopubic junctions during acute stage.

FIG. 4-B
Case 4. Healed ischiopubic junctions nine months later.

Fig. 5

Case 5. Lesion of ischiopubic junction during acute stage.

Case 5. A white boy, eight years old, was brought to the hospital because of pain in the left hip and inability to walk. He came from a sheltering home and no detailed history could be obtained.

The hip was not limited in motion, but gave evidence of muscle spasm on extreme flexion and abduction. The descending ramus of the pubis was tender. Roentgenograms showed rarefaction and roughening at the left ischiopubic junction.

The general examination revealed that the boy was acutely ill with bronchopneumonia. For this reason he was transferred to the Charity Hospital, where he died the following morning. No autopsy was performed.

Although the data in this case are inadequate for complete study, they are included to illustrate the condition further. It is of interest that the child was brought to the hospital because of pain in the hip and that the acute pulmonary condition was completely overlooked.

DISCUSSION

Ischiopubic osteochondritis occurs only during the first decade of life, since the conjoined rami of the ischium and pubis are completely ossified and fused by the tenth year. The average age of the patients in this series is seven and one-half years.

Little is known about the etiology. There has been much speculation, but very little factual proof. Probably the two factors which have been given the greatest amount of consideration as causative agents are trauma and infection, with the weight of evidence in favor of the former. Children at play are constantly exposed to varying degrees of injuries because they have not yet developed the instinct of self-protection. This is well illustrated by the fact that football injuries are more common among children than among college students. It is altogether likely, even though not always plainly evident from the history, that patients who develop osteochondritis have suffered sufficient strain to affect the susceptible epiphyseal region. A history of definite trauma was obtained

from one patient in this series and a history of suspected trauma in another; in the remaining three, no statement was made regarding injury. In several of Wülfing's patients cultures were taken from the lesions, but these failed to produce definite results. No cultures were taken from any patients in this series. A clear history of antecedent infection was elicited in only one. In this patient an acute attack of otitis media was followed in a few days by the symptoms of osteochondritis. Two patients had enlarged and infected tonsils, but it is questionable whether the tonsillectomies had anything to do with the resolution of the epiphysitis.

The diagnosis should offer no particular difficulty if the possibility of the existence of this lesion is kept in mind. The symptoms and findings on physical examination are quite typical. Pain referable to the hip or groin is essentially present. The child walks with a definite limp and protects the affected side, if the pain is not so acute as to prevent weight-bearing altogether. Tenderness along the descending ramus of the pubis, with or without swelling, is characteristic and immediately suggests the diagnosis. Muscle spasm, particularly of the adductors, is constantly present in varying degrees. No swelling or tenderness is demonstrable about the hip joint. The temperature may be within normal limits or it may be elevated. Moderate leukocytosis is usually present. The roentgenogram is typical and establishes the diagnosis.

The treatment is essentially the same as that for allied bone-growth disturbances and consists of recumbency with sufficient traction to the affected leg to overcome muscle spasm. In the patients here reported the lesion responded rapidly to such care and eventually resolved completely by ossification of the ischiopubic junction.

Ischiopubic osteochondritis is of clinical importance in that it may simulate hip-joint disease very closely, both in symptoms and in signs, and, if one is not mindful of the possibility of epiphysitis in the ischiopubic region, the lesion might easily be overlooked. Another diagnostic pitfall is confusion with acute osteomyelitis, which has clinical manifestations in common with osteochondritis. In both diseases, local tenderness, fever, and leukocytosis are characteristic. Swelling and redness, however, are more often found in osteomyelitis than in osteochondritis. The general appearance of the patient is of some significance; it is more apt to bear evidence of a systemic reaction in osteomyelitis. The roentgenogram will usually decide the matter. In osteochondritis, the characteristic change is rarefaction with roughening and thickening; in acute osteomyelitis, one would look for a destructive lesion with periosteal reaction. The differentiation is very important because the treatment of osteochondritis consists of rest, while that of osteomyelitis is usually surgical.

SUMMARY

In the five cases of ischiopubic osteochondritis described, the average age of the patients was seven and one-half years. No further light is shed on the etiology, but the belief is expressed that of the two factors, trauma

and infection, the former is the more important. The symptoms were principally limitation of motion of the hip and tenderness along the pubic ramus. The roentgenograms showed rarefaction, roughening, and irregularity at the ischiopubic junction. The treatment consisted of recumbency and traction to the affected hip. Recovery was complete, clinically and roentgenographically, in every patient except one, who died of intercurrent pneumonia.

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normally of sufficient depth. It might be mentioned, however, at this point that the stability of the reconstructed hip joint would be greatly impaired if the operation were employed in any cases presenting either congenital or acquired deformation of the acetabulum itself.

2. *The maintenance of a satisfactory range of movement:* The mobility obtained by this type of reconstruction operation is largely due to the fact that the cartilage of the acetabulum is not in any way disturbed at the operation, and care is always taken to keep the upper extremity of the femur protected by a thin fibromuscular layer of tissue. This means that, as there are no raw bony surfaces opposed to the cartilage of the acetabulum, an opportunity is given for free mobility. The active power of the transplanted abductors, reenforced by the flexor and extensor muscles of the hip, permits a wide range of active movement. In abduction particularly, there is no bony block possible, as the whole trochanteric region moves under the upper rim of the acetabulum.

3. *The increase in length of an already shortened extremity:* The preoperative shortening of these limbs is dependent in great part on the upward riding of the greater trochanter above the superior rim of the acetabulum. In one case the shortening was as much as two and one-half inches, while, after operation, it was reduced to only one-half an inch.

In order to study the average shortening that might follow the placing of the greater trochanter within the acetabulum, a number of adult femora were picked at random in the Anatomical Laboratory at the New York University Medical College. As shown in Figures 1-A and 1-B, the distance between parallel planes passing through the tip of the greater trochanter and the superior surface of the head of the femur ranged between zero and three-

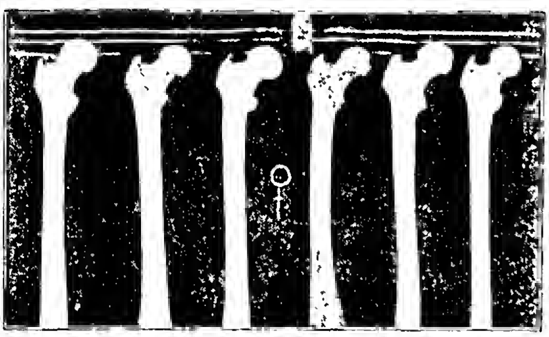

Fig. 1-A

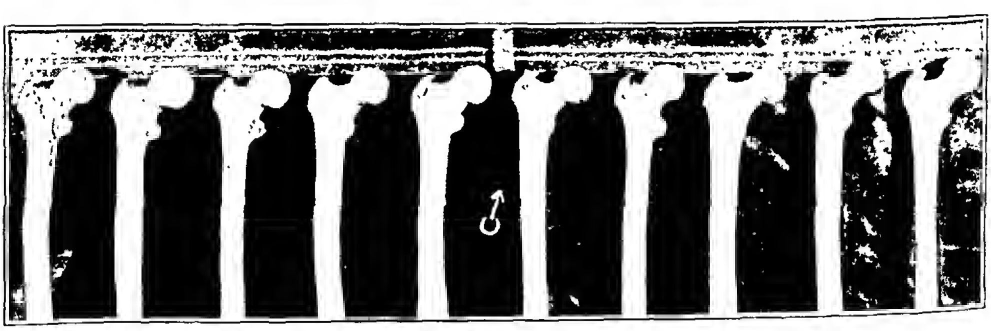

Fig. 1-B

A study of these femora will disclose the slight degree of shortening that follows when the greater trochanter is placed within the acetabulum. As these parallel lines are separated one-half an inch, it may be noted that the affected extremity is usually shortened about one-half an inch less than the sound side by this type of reconstruction operation.

quarters of an inch, the angle of the neck in the female femora being consistently greater than in the male. In none of the femora, however, did this difference exceed three-quarters of an inch. This observation agrees rather closely with the clinical findings noted in the cases operated upon, in that the shortening between the two extremities after operation was never more than three-quarters of an inch and sometimes considerably less. There has been no attempt made to compensate completely for this shortening for at least a year after operation, as it is felt that the slight degree of abduction produced at the hip by the shortening adds to the stability and integrity of the reconstructed joint.

The question of the relief from pain is an important one, as pain is an almost constant complaint in the old ununited cases. It is probably due to several factors, but is largely dependent upon a mechanical one which is relieved by the reconstruction operation. The degree of discomfort after the first few months of operation has varied, but in none of the cases in which an operation was performed has it proved to be a troublesome feature. Baking and massage to the muscles about the hip during the early months of postoperative weight-bearing have been found to be of benefit in some cases; others have not required this treatment.

POSTOPERATIVE CARE

At the end of the operation, a plaster spica is applied, with the limb in from 20 to 25 degrees of abduction and complete extension at the hip. At the end of two weeks, a posterior shell of plaster is removed from the

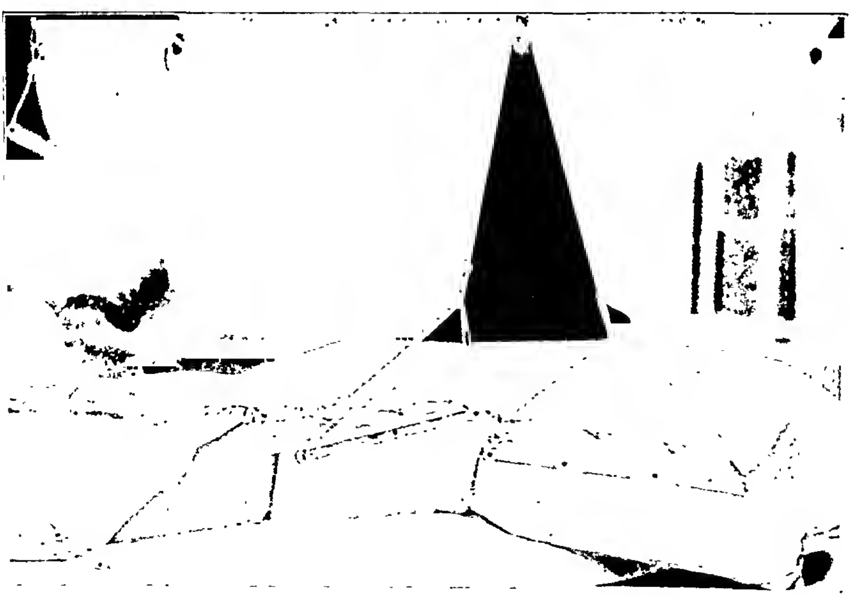

FIG. 2

Showing the limb suspended in a felt sling which may be controlled by pulleys. The patient should be encouraged to move the limb actively in all directions, but especially in that of abduction.

Case No.	Name	Age (*Years*)	Sex	Shortening: Preoperative (*Inches*)	Shortening: Postoperative (*Inches*)	Preoperative History	Operation Performed	Complications	Last Report
1.	Mrs. G. R.	55	Female	1½	¾	Nine months before admission slipped and fractured right hip. Fracture reduced and spica applied. Non-union and absorption of neck resulted.	April 10, 1931	None	July 1937 (over 6 years after operation). Doing housework, walks several miles daily. No pain. AGE *—180; AGF †—90.
2.	Mr. F. M.	70	Male	1	½	Severe pain on weight-bearing. Fractured left hip 6 months before admission. A spica was applied. Non-union resulted.	August 11, 1932	None	December 1936 (over 4 years after operation). Quite active. Stable hip. AGE—180; AGF—100.
3.	Mrs. M. N.	56	Female	1	½	Several months before admission fractured left hip. A spica was applied with subsequent non-union and absorption of neck.	November 10, 1932	None	November 1936 (4 years after operation). At work for past 3½ years. Walks quite well for long distances. AGE—180; AGF—90.
4.	Mrs. A. N.	50	Female	1½	½	Poor general condition. Blood sugar 190 milligrams. Movement of right hip painful. Non-union and neck absorption.	July 20, 1933	Fell 1 year later and dislocated trochanter. Refused further treatment.	January 1936 (over 2 years after operation). Uneventful convalescence. Left hospital 8 weeks after operation, walking well. Does housework and walks with crutch.
5.	Mr. J. B.	68	Male	1½	½	Fractured right hip 5 years before admission. Non-union, severe disability, poor general condition. AGE—160; AGF—140.	August 9, 1933	A psychosis developed 4 weeks later and patient was moved to psychopathic ward.	Six weeks after operation patient was walking about psychopathic ward in a short spica. Transferred to mental institution, and a year later died from natural causes.
6.	Mrs. R. S.	48	Female	1	½	Fractured left hip one year before admission. Non-union, neck absorption, and head necrosis. Very painful hip. AGE—160; AGF—130.	October 18, 1933	None	November 1936 (3 years after operation). Walks well without support. Painless, stable hip. Doing housework. AGE—180; AGF—90.
7.	Mrs. J. G.	45	Female	1	½	Fractured right hip one year before admission. Walking with crutches. Non-union,	July 25, 1934	None	August 1937 (3 years after operation). Walks well, does housework. Stable. freely

TABLE I (*Continued*)

8.	Mrs. J. L.	69	Female	2½	½	Fractured right hip 1½ years before admission. Had been in bed ever since accident. Severe deformity.	August 27, 1934	None	August 1936 (2 years after operation). Walks without any support. Stable, painless hip. AGE—180; AGF—100.
9.	Mrs. I. B.	56	Female	1¾	½	Fell and fractured left hip 1½ years before admission. Non-union with neck absorption and head necrosis. Persistent pain.	April 8, 1935	Staphylococcus infection of soft tissues about hip. Discharged 3 months after operation.	June 1937. Walks without cane. No complaint of pain in hip. Presents stable joint with limited motion. AGE—180; AGF—150. Good abduction.
10.	Mrs. R. H.	45	Female	½	½	Fractured left hip 4 months before admission. Spica applied. Non-union. AGE—180; AGF—160.	June 4, 1935	None	November 1936. Walks with cane, does housework. Freely movable hip. AGE—180; AGF—90.
11.	Mrs. L. S.	47	Female	2	¾	Fractured right hip 2 years before admission. Non-union. Walked with crutches.	August 7, 1935	Convalescence uneventful until 19th postoperative day. Patient suddenly became cyanotic and dyspneic. Vomited several times and a few hours later expired. Cause of death undiagnosed. No autopsy permitted, but examination of wound showed no evidence of infection. Temperature after operation never more than 101 degrees.	
12.	Mrs. M. S.	60	Female	1	½	Fractured left hip 3 months before admission. Spica applied. Non-union with neck absorption.	December 11, 1935	None	December 1936. Very active, walks without support, presents painless hip. AGE—180; AGF—90.
13.	Mrs. C. O.	60	Female	½	½	Fractured left hip. Fixation by Smith-Petersen nail 8 weeks later. After 7 months, apparent bony union, and nail removed. X-ray few days later showed frank non-union.	April 1, 1936	None	August 1937. Does housework, presents painless, stable hip. AGE—180; AGF—130.
14.	Mrs. M. McG.	53	Female	1	½	Fell and fractured right hip 6 weeks before admission. No treatment. Non-union with marked neck absorption.	August 26, 1936	None	June 1937. Walks without cane, presents stable, painless joint with limited motion. AGE—180; AGF—150. Good abduction.
15.	Mrs. A. K.	34	Female	1	½	Fractured right hip March 14, 1936. Hip pinned 10 weeks later. Non-union resulted.	October 23, 1936	None	September 1937. Does housework. Presents stable, painless hip with limited motion.

* AGE=Angle of greatest extension. † AGF=Angle of greatest flexion.

Fig. 3-A

Fig. 3-B

Fig. 3-A: Mrs. G. R. Right hip before operation.

Fig. 3-B: Mrs. G. R. Right hip six years after operation.

foot and leg. This permits the patient to begin early active movement at the knee, and has been a very useful procedure, as in many of the cases there is a good deal of knee stiffness following previous immobilization in plaster. The posterior shell is reapplied when the patient is turned on his back, but is removed several times a day when the patient is turned over, in order that he may exercise the knee while lying on his stomach. At the end of four

weeks, the plaster is completely removed and a well-fitting posterior shell or felt sling (Fig. 2) supports the extremity, and overhead suspension permits active and passive movement at the hip. This is continued for the following two weeks, a pillow being placed between the thighs to prevent adduction during this period. Ordinarily, at the sixth or seventh week after operation, the patient is gotten out of bed and encouraged to walk with crutches or walker. Physiotherapy may or may not be helpful at this stage, but every effort is made to encourage the patient to discard all forms of support as soon as possible. These older people usually need to be encouraged, as many of them are prone to become apprehensive of weight-bearing. This short six-week period of convalescence in bed is felt to be a very important item in the care of the elderly patient, and every attempt is made in the average case to have the patient out of bed and bearing weight six or seven weeks after operation.

COMPLICATIONS

There was one death which occurred as a possible complication from the operation. This patient, aged forty-seven, had a perfectly uneventful convalescence up to the nineteenth postoperative day and then, while being turned by the nurse, she suddenly collapsed and died in a few hours. Examination of the wound showed no evidence of infection, and the cause of death was assigned to a pulmonary embolus. One other patient has since died from natural causes.

In another case a rather persistent infection developed in the soft tissues about the hip which delayed convalescence. The bone was apparently not involved and the end result has been satisfactory. The patient presents a good range of motion and excellent stability, and at present is walking without any support and doing her usual housework.

The only case in which the stability has been impaired is that of a woman, aged fifty, who was operated upon in 1933 and left the hospital at the end of eight weeks, walking with the aid of a crutch. This patient's convalescence was uneventful and she discarded her crutch a few weeks later. During the following year she carried on her housework without any difficulty. At the end of that time, she slipped and fell with the limb markedly adducted. Dislocation of the upper extremity of the femur occurred, but after a few weeks the patient went back to her housework, using a crutch for support. This patient has refused to return to the hospital for roentgenograms or operative interference and is able to be up and about with the use of one crutch. This case, however, is regarded by us as a failure.

END RESULTS

At present thirteen of these fifteen patients are living and have been recently examined. With the exception of the one failure, each of the other twelve presents an excellent range of active and passive movement, stability of the reconstructed hip, and increase in the length of the ex-

Fig. 4-A
Mr. F. M. Left hip before operation.

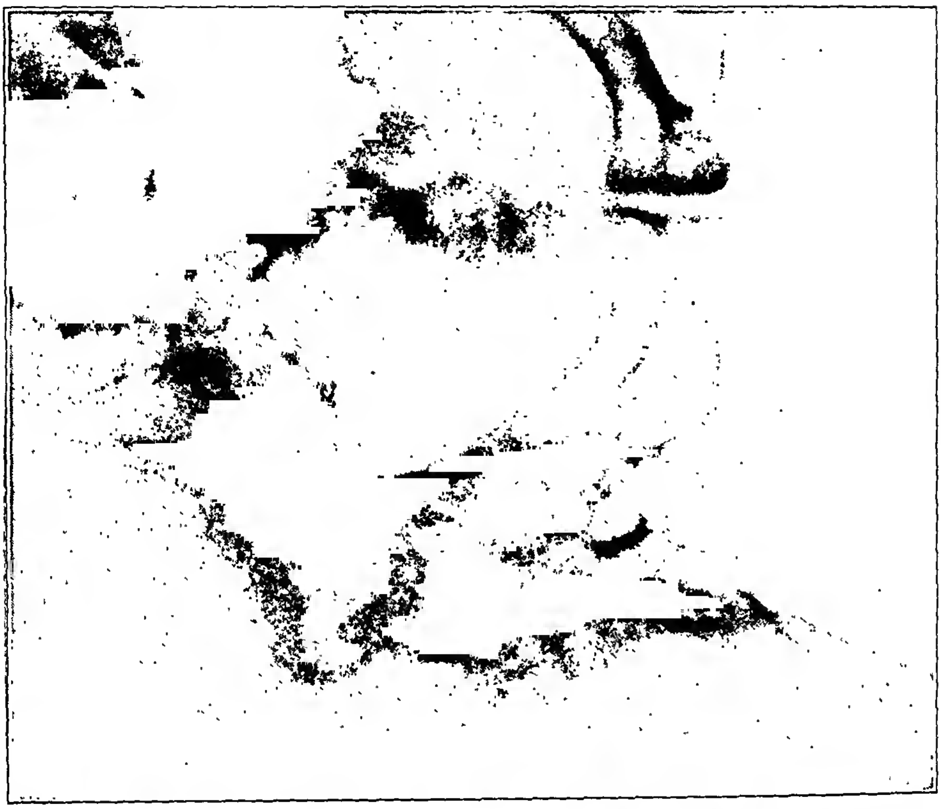

Fig. 4-B
Mr. F. M. Left hip four and one-half years after operation.

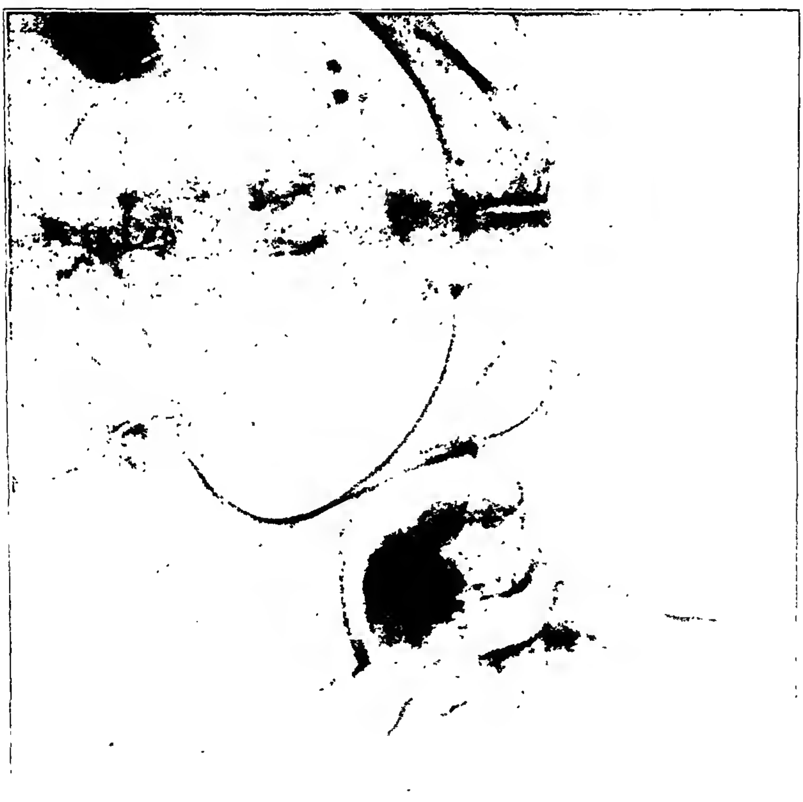

FIG. 5-A
Mrs. J. S. Right hip before operation.

FIG. 5-B
Mrs. J. S. Right hip four years after operation.

tremity. These cases have all had a careful follow-up as shown in Table I. Two of these cases in which this type of reconstruction operation was performed four or more years ago, as well as one case in which the same operation was performed by Dr. Armitage Whitman, are reported in detail. The end results of any proposed surgical procedure are always of importance and value, so that the following histories of these older cases, as well as their roentgenograms, are thought to be of especial interest.

CASE REPORTS

Mrs. G. R., fifty-five years of age, fell in August 1930 and fractured the right hip (Fig. 3-A). Non-union resulted, with shortening of one and one-half inches and complete absorption of the femoral neck. The reconstruction operation described was done on April 10, 1931. At present, six years after operation, the patient is quite active, walks rapidly, and is able to go up and down stairs with ease. She states that she can walk several miles without tiring. The hip is stable with an excellent range of active movement. There is shortening of three-quarters of an inch. A recent roentgenogram is shown in Figure 3-B.

Mr. F. M., seventy years old, fractured his left hip (Fig. 4-A). Non-union resulted, with absorption of the neck and one inch of shortening. The patient was operated upon at Bellevue Hospital on August 11, 1932. A reconstruction operation of the type described was performed. Plaster was removed at the end of four weeks and the patient was allowed to bear weight at the end of six weeks. He was discharged several weeks later to a country convalescent home and presented about 30 degrees of flexion at the hip and a free range of abduction. At present, over four and one-half years after operation, he presents a good range of movement in all directions with only one-half an inch of shortening. The appearance of the reconstructed hip is shown in Figure 4-B.

Mrs. J. S., aged fifty-six, was seen at the Hospital for the Ruptured and Crippled on January 8, 1932. She was unable to walk except with the aid of crutches and complained of severe pain on any movement of the right hip. She had fractured the hip two years previously, non-union had resulted, and at the time of admission to the hospital she presented a frank non-union with absorption of the neck, necrosis of the head, and one and one-half inches of shortening. (See Figure 5-A.) Dr. Armitage Whitman performed the type of reconstruction operation described in this paper, and four weeks later the plaster was removed and overhead swinging traction apparatus was instituted. Seven weeks after operation the patient was discharged from the hospital and her convalescence was uneventful. At present, four years after operation, she is doing her usual housework, is able to walk up and down stairs without the use of a cane, and presents an excellent range of active and passive movement. She has a painless stable reconstructed hip, and a recent roentgenogram is shown in Figure 5-B.

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THE SCHANZ OSTEOTOMY FOR FRACTURES OF THE NECK OF THE FEMUR*

BY HERMAN C. SCHUMM, M.D., MILWAUKEE, WISCONSIN

Since 1894, when Kirmisson advised the use of the subtrochanteric osteotomy in "certain cases of congenital dislocation of the hip", there have been several waves of enthusiasm in regard to the use of this method or its modifications for various conditions affecting the stability of the hip joint. Von Baeyer and Lorenz with their bifurcation operations and Schanz with his controlled subtrochanteric osteotomy are among the more important advocates of the use of this method, especially in cases of ununited fracture of the neck of the femur. Brackett, in 1912, called attention to the importance of controlling the fragments following osteotomy of the upper end of the femur. It remained for Schanz to correlate these findings and to present the mechanical principles and the technique of the operation that now bears his name.

The keystone of his ideas on the mechanics underlying the treatment of fractures of the neck of the femur is best given in his statement: "Through the angulation of the neck, the fracture site is placed below the head and the body weight no longer pushes the head downward past the fracture surface but directly against it. This provides more favorable weight-bearing relations and may even lead to late bony union." Pauwels, a former assistant of Schanz, has given us a more scientific and elaborate explanation of this principle.

The indications for this operation are: (1) disability due to instability of the hip, which may be accompanied by varying degrees of pain and fatigue, and (2) those cases of delayed union or non-union with coxa-vara deformity in which there is still a chance to effect a union by relieving the shearing force present.

In studying our cases for operation, we have divided them into two classes: (1) cases in which an insidiously developing coxa vara indicates a prospective non-union, and (2) cases of definite non-union with absorption of the neck, in which there is a marked upward riding of the shaft, so that the fracture surfaces have slid by one another. This classification is a guide to the site for osteotomy. In the first group the osteotomy is placed just above or as near to the lesser trochanter as possible and is often spoken of as the high osteotomy (Figs. 2 and 3); whereas in the second it is placed several centimeters lower and is called the low osteotomy (Fig. 8). This low osteotomy is the true Schanz osteotomy. As Schanz pointed out, an anteroposterior roentgenogram, taken with the affected leg in maximal adduction, is of importance in determining the degree of angulation desired and, in the low osteotomy, is of help in definitely

* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons, Cleveland, Ohio, January 13, 1937.

locating the site. The angle corresponds to that formed by the upper portion of the adducted shaft and the long axis of the body. In the low osteotomy, this angle varies between 35 and 60 degrees. In the high osteotomy, the angle should be somewhat greater, varying between 45 and 70 degrees. The site for the low osteotomy is at the point of closest approximation of the shadow of the shaft to the pelvic rim, which is usually at the distal end of the tuber ischii.

We do not feel that a lateral view of the hip gives any additional help in determining the site or the degree of angulation.

OPERATIVE TECHNIQUE

The technique used by us is essentially that of Schanz. With the patient on the fracture table and the affected hip elevated with a sandbag, a lateral incision is made, centering over the elected site for osteotomy. With the femur exposed, holes are drilled through the shaft into which the special Schanz screws are placed. One hole is drilled above and another below the site of the proposed osteotomy, leaving a minimal working space of at least five centimeters between the holes. Instead of drilling at right angles to the shaft, as Schanz suggests, we prefer Riedel's modification of drilling obliquely at the desired angles, so that, when the screws are inserted and then brought parallel, the fragments are in the desired position. A protractor, or a piece of stiff tin foil cut to the desired angles, is used as a guide for the drill holes. It is preferable that the angle of the hole in the upper fragment be approximately one-third of the total angle desired and that the angle of the hole in the lower fragment be the remainder.

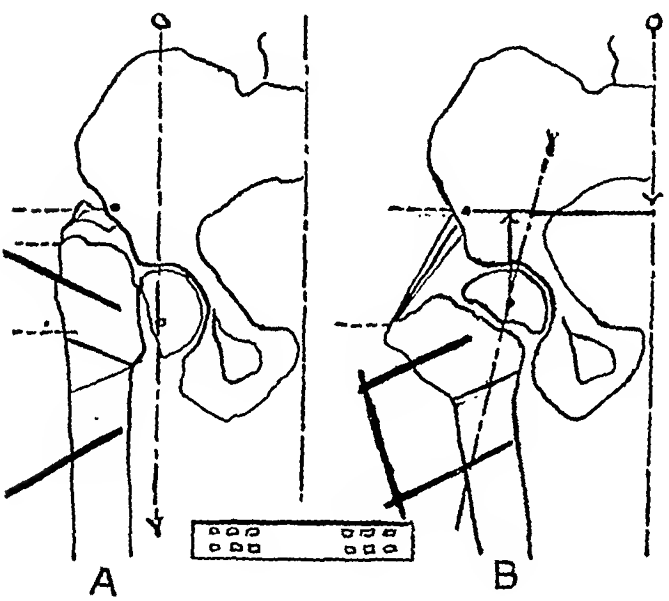

Fig. 1

A: The oblique insertion of screws (Riedel) allows greater working space than when the screws are introduced perpendicularly to the shaft, as in a true Schanz osteotomy. Note relaxation of muscles attaching to greater trochanter due to upward riding. Inefficiency of these muscles is also due to loss of lever action.
B: Shows screws parallel after angulation of femur and securely fixed by use of Riedel plate. Note effect on musculature following osteotomy.

After the screws have been inserted, and not before, the femur is divided. In the high osteotomy, a wedged osteotomy with the base on the lateral aspect is desirable, but in the low we have found a modified transverse osteotomy to be more efficient. The *modification* consists of

Fig. 2

Fracture of the neck of the femur with non-union two years after fracture.

Fig. 3

Same patient as in Fig. 2 after high Schanz osteotomy, showing solid bony union. Result excellent. Patient walks without limp. No pain in hip. Occasional pain in back and knee.

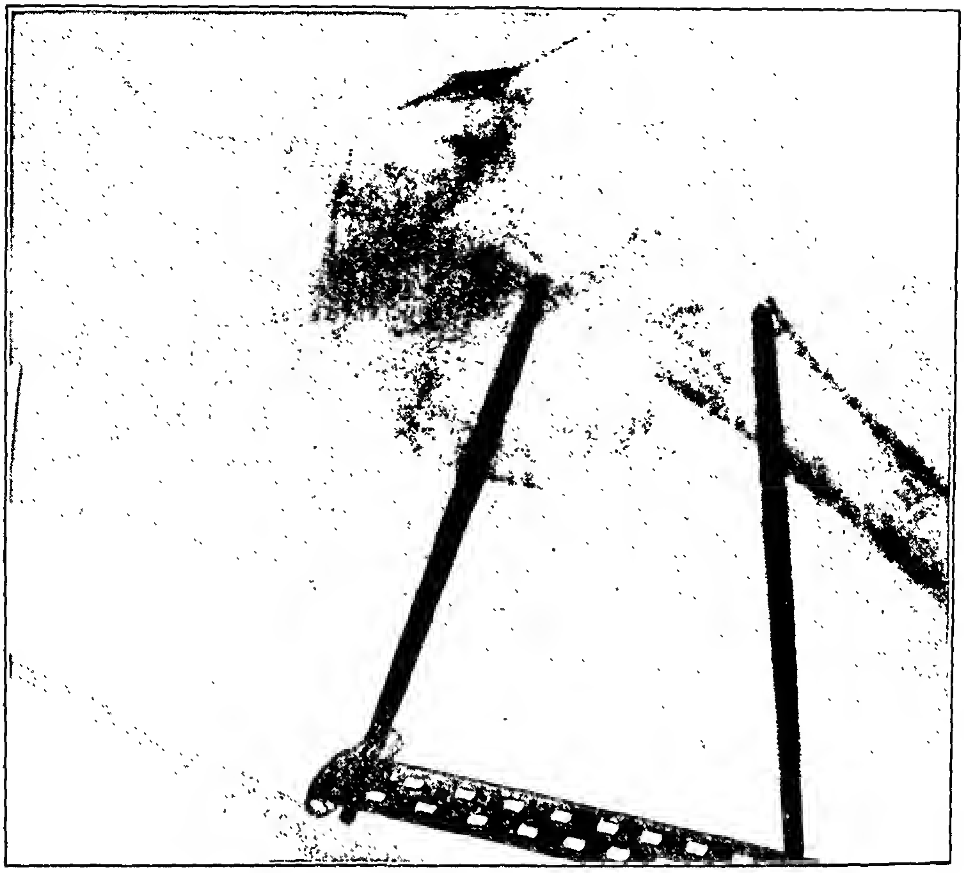

FIG. 5

Same patient as in Fig. 4, showing position of fracture following a low Schanz osteotomy, with Schanz screws and Riedel plate in place.

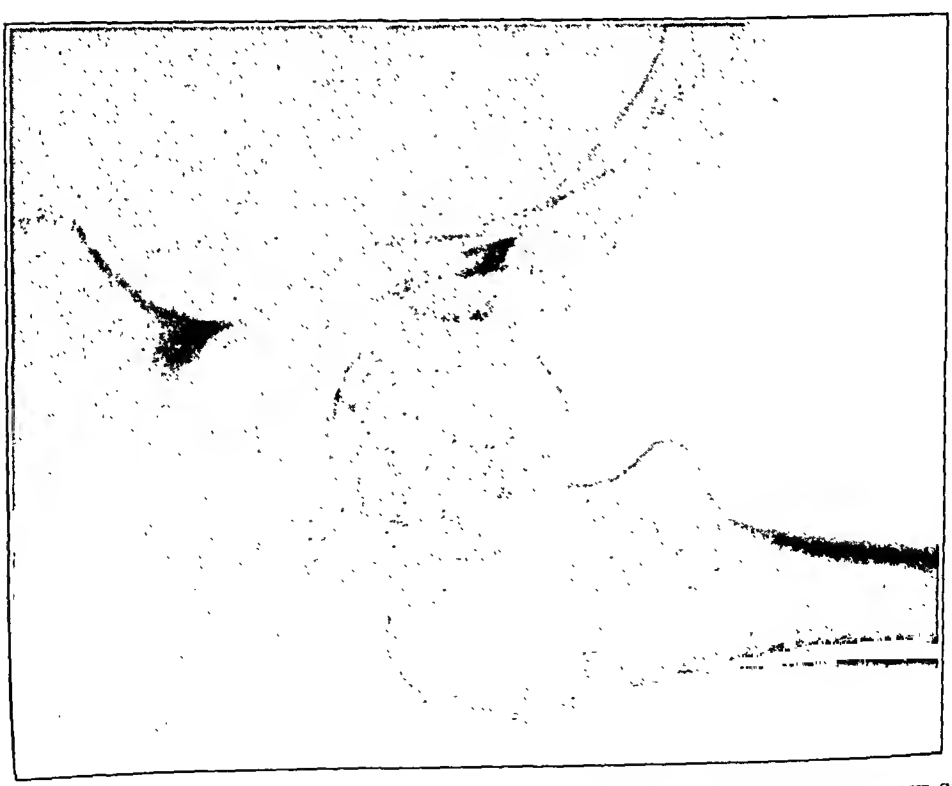

FIG. 4

Ununited fracture of the femur four months following fracture.

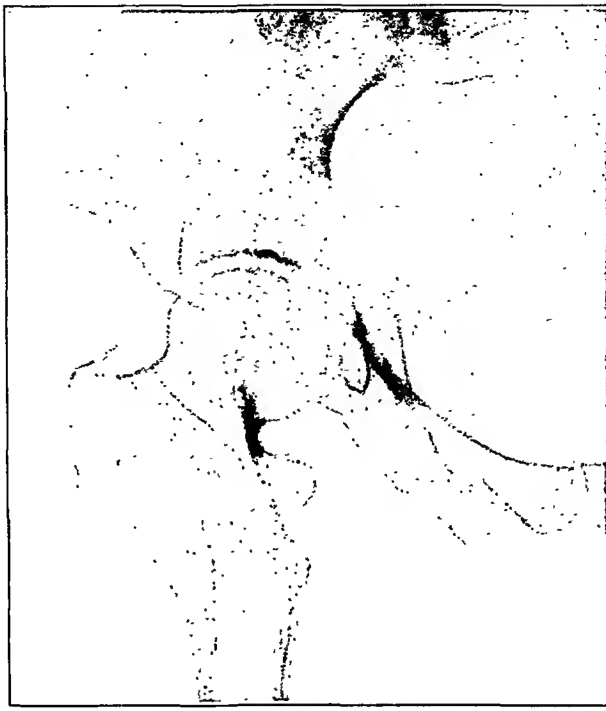

Fig. 6

Same patient as in Figs. 4 and 5. Roentgenogram one year following Schanz osteotomy, showing solid bony union of ununited fracture. Result excellent. Patient climbs stairs and laces shoes without difficulty.

leaving a projecting tongue extending upward on the lateral aspect of the lower fragment, which engages in the medullary cavity of the upper fragment, thus assisting to hold the fragments in position. By dividing the medial half of the shaft first, one can help prevent a splintering of the shaft, which is occasionally experienced when doing osteotomies on older people. The wound is then closed in layers, the screw ends projecting from the wound. To hold the desired angle, the screw ends are securely fixed by attaching a Riedel plate. (See Figures 4, 5, and 6.) A large, plaster spica is applied, including the well leg down to the knee.

AFTER-TREATMENT

As soon as the patient is comfortable and the cast has thoroughly dried, a window is cut in the cast over the knee to permit passive motion of the patella and gentle massage of the knee. At the end of six weeks, through a second window exposing the operative wound, the stitches and screws are removed. This can be done with but little pain to the patient. At the end of the first postoperative week, a check-up roentgenogram is taken. At the end of the eighth week, the cast is removed and another check-up roentgenogram is taken. If there is not sufficient callus present, a light splint is applied, holding the hip in abduction.

For the first week or two following removal of the cast, the patient is given sling-suspension exercises in bed and baths in the Hubbard tub. At the end of the second week, an additional check-up roentgenogram is taken and, if the condition appears favorable, the patient is permitted to be up with crutches.

It is claimed that the advantages of this method are: (1) safety and simplicity, and (2) increased stability with a corresponding lessening of, or

FIG. 7

Ununited fracture of the neck of the femur. Roentgenogram showing position at time of operation one year following fracture.

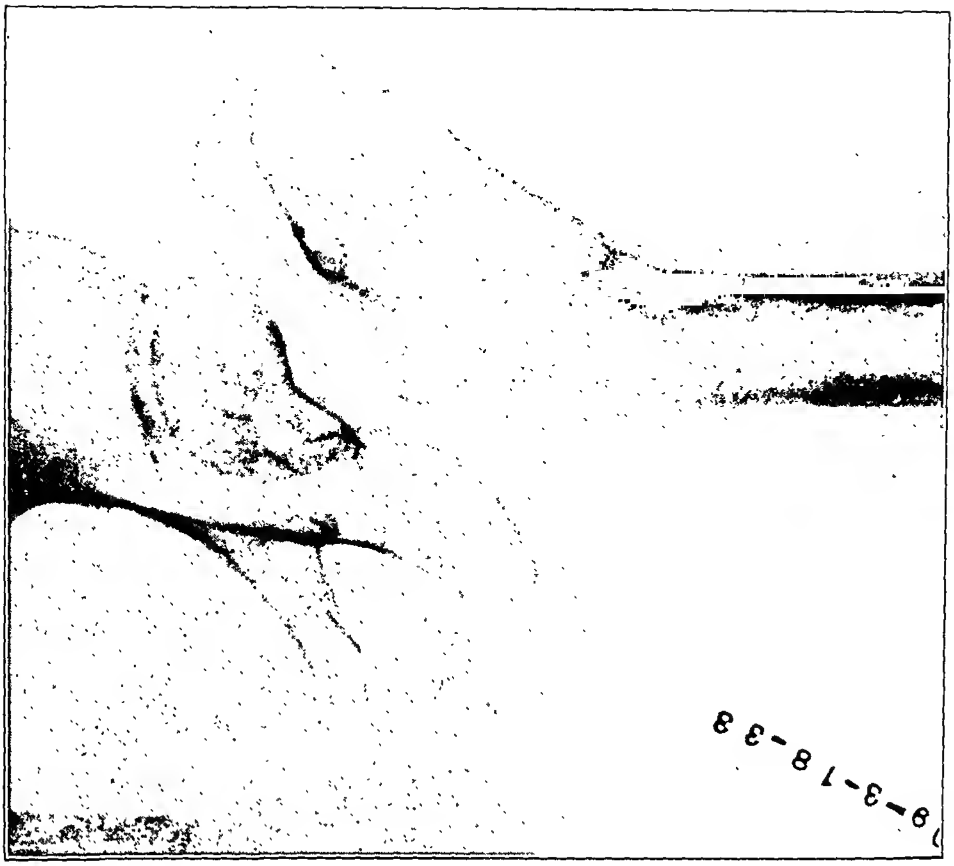

FIG. 8

Same patient as in Fig. 7 after low Schanz osteotomy. Result very satisfactory. Patient walks without pain or fatigue, although with a moderate limp.

entire freedom from, pain and fatigue. The increased stability is considered due to several factors: namely, (1) improved leverage conditions favoring the gluteii; (2) improved efficiency of the gluteii themselves when they are put under tension by the depression of the trochanters; and (3) contact of the angulated upper fragment against the pelvic wall. (See Figures 1,*A*, 1,*B*, 7, and 8.)

CLINICAL FINDINGS

Our series consists of thirteen cases of ununited fracture of the neck of the femur, in which operations were performed by the late Dr. Frederick J. Gaenslen, by Dr. Walter P. Blount, or by the author, as well as an additional fifteen cases in which the Schanz osteotomy was performed for other unstable conditions such as old congenital dislocation of the hip, making a total of twenty-eight cases. In the series of hip fractures, four of the osteotomies were of the high type and nine were of the low. The ages of these patients ranged between twenty-two and seventy-nine years, the average age being fifty-five years.

In addition to the ordinary hazards of age, the following preoperative complications were found: serious cardiac involvement in two cases; pernicious anaemia in one case; generalized fibrocystic disease in one case; a definite mental depression in one case; marked osteo-arthritis of the hips in one case; and osteo-arthritis of the hip and knee of the affected side in one case.

There have been no deaths in this series, nor were there any deaths in the series of fifteen cases in which operations were performed for conditions other than fracture of the femoral neck. In the combined series, there was but one case of shock sufficient to cause us even the slightest worry—a surprisingly low number, considering the ages and preoperative complications.

In only one case, that in which a high osteotomy was performed, did the limp completely disappear. In six cases, the stability was definitely improved and the limp was but slight. As regards motion, flexion was limited in only two cases, in both of which an osteotomy of the high type was performed. The other motions were more or less limited in all cases. Three of the patients still complain of definite pain in the leg, either in the region of the hip itself or in the thigh. One of them has a marked osteo-arthritis of both hip and knee with definite limitation of motion in the knee, while another complains of pain in all of her joints, but especially in the hip, although no definite pathology has been found to account for the pain. This patient can sit without difficulty and walks with only a slight limp without support, although she prefers to use a crutch. The third patient had a very definitely delayed union at the site of the Schanz osteotomy, with a resulting loss in angulation. When she was finally permitted to be up and about, she fell, fracturing the other hip. Superimposed on this is a bad heart that has necessitated bed treatment. The remaining patients do a partial or a full day's work, although toward the

end of the day most of them complain of a sense of fatigue in the operated hip. This sense of fatigue lessens after the first year.

The three patients with pain do not admit any improvement following the operation, while the others admit, or in most cases have volunteered the information, that they have been definitely benefited. Nine of the patients walk without support in the house, although all but two use a cane, or a cane and a crutch, when they go out on the street. Five patients state that they are able to walk up and down stairs without difficulty if they can put their hands on a rail to steady themselves. Two others can walk up and down stairs, but they have to go somewhat slowly and use a cane for support. Three patients have not stated their ability along this line. The remaining three, for one reason or another, have not tried.

Genu valgum is a condition that should be watched for, especially preoperatively. Those cases with more than 7 degrees of genu valgum deserve special consideration. The valgus deformity is apt to become much more pronounced postoperatively, especially following the low operation, and will be a factor in postoperative pain. The patient should be advised of this possibility. In the more marked cases, we now consider the question of correcting the deformity by a supracondylar osteotomy at the time we do the Schanz osteotomy, or we plan on doing it at a later date. Four of our patients have had an accompanying or delayed supracondylar osteotomy. In one case there was a slight delay and in another a very definite delay in union at the site of the Schanz osteotomy, but there has been no case of permanent non-union. Based on the symptoms and physical findings, the results in this series were considered good in seven cases, fair in three cases, and poor in three cases. The unsatisfactory results in the last three we attribute to poor or faulty judgment either in selection of the patient or of the site of operation.

CONCLUSIONS

1. The Schanz osteotomy is as simple and as shock-proof an operation as we have found, for the conditions for which it has been used.
2. It results in a definite increase in stability of the hip, without seriously interfering with the motions necessary in sitting, mounting stairs, or in dressing.
3. Because of increased stability, there is definite relief from pain and fatigue.
4. The most important complications are increasing genu valgum, delayed union or non-union at the site of osteotomy, and loss of angle at the site of osteotomy.

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THE VALUE OF EARLY WEIGHT-BEARING IN THE TREATMENT OF FRACTURES OF THE NECK OF THE FEMUR

WITH A REPORT OF TWENTY-FOUR CASES *

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In the management of fractures of the neck of the femur there has always been considerable uncertainty about the ultimate healing and function. This has arisen from two factors: (1) Many fractures at the hip occur in old people in whom the nutrition of the injured tissues and their reparative processes are admittedly very poor; (2) experience has demonstrated that in a large proportion of cases the fractures actually do not heal, and severe disability ensues. These facts have led in general to two types of treatment,—namely, prolonged immobilization and rest in bed over a period of many months, and the utilization by operative intervention of some foreign material, like nails or wires, to contact and appose the fragments, in the hope that their close apposition will favor and assure union.

Several years ago it occurred to me that, if weight-bearing and friction stimulate callus formation in an ancient non-union of a fractured tibia, they might serve the same purpose in fractures at the hip. Consequently, I determined to anticipate non-union in every fracture at the hip, and to institute weight-bearing early, almost immediately after the reduction, hoping thereby to prevent a large percentage of non-unions. However, if the patient is to bear weight on the injured member, two conditions must be obtained,—satisfactory reduction and adequate immobilization.

Many years ago Royal Whitman taught us the abduction treatment for fractures at the hip. This method provided the opportunity for apposing the fragments by traction, inward rotation, and abduction. Thus the shortening was overcome, the fragments were brought into contact, and the corrected attitude of the limb was maintained by a long plaster-of-Paris spica bandage. Equality in length of the injured and well limbs and a roentgenogram showing the fragments in apposition were the criteria of reduction. The principles of the reduction and the immobilization were correct and remain so. Some of the details of the treatment, however, have recently been advantageously modified.

It had been the custom, in order to avoid pressure sores, to apply stockinet and many layers of sheet cotton over the skin under the plaster spica. This did make a comfortable dressing, but, as the cotton became compressed, it was found that there was too much room between the skin and the plaster, reducing the effectiveness of the immobilization. On a number of occasions, slipping of the fragments actually took place in the

* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons, Cleveland, Ohio, January 13, 1937.

plaster spica. This can be prevented by the Leadbetter technique which I have used in all transcervical fractures. In order to prevent any possible slipping of the fragments in the plaster, I take the extra and very important precaution of placing one or more reverses around the groin and the buttock. These are carefully molded about the descending ramus of the pubic bone and the ischium. This detail maintains the required length of the limb between the sole of the foot and the pelvis, prevents displacement of the fragments, and materially enhances the protection afforded by the splint. A postoperative roentgenogram is made directly after the plaster dressing is finished, in order to be certain that the reduction is being maintained in the plaster spica. In the cases of intertrochanteric fractures, the patient is placed on a Hawley table with the padded perineal bar pressing against the symphysis pubis. The well limb is supported in moderate abduction. By traction on and inward rotation and abduction of the injured limb, the deformity is corrected and a plaster-of-Paris spica bandage is applied in exactly the same manner as for a transcervical fracture. In comminuted intertrochanteric and subtrochanteric fractures of the femur the deformity is likewise reduced by manipulation, preferably with the aid of the fluoroscope to be sure that the general longitudinal alignment is satisfactory, and a plaster spica is applied in the manner indicated. If the reduction, as shown by the postoperative roentgenogram, is satisfactory, we may assume that the splint will maintain it and will permit the movement of the patient without fear of slipping of the fragments.

The patient is allowed to remain in bed for several days to get used to the plaster support. On the third to the seventh day after the reduction the patient is taken out of bed and allowed to stand up for a few minutes. This procedure is repeated on each of several days, during which time the patient rapidly learns that the upright position in the plaster is not only possible but comfortable. He is provided with crutches and after an additional period of from one to four or five days, depending upon his ambition, he learns to walk. By the tenth to the fourteenth day after the reduction the patient is able to walk about his room, and may be discharged from the hospital. Thereafter the patient gets out of bed at least once a day, and often two or three times a day, remaining standing or walking and *bearing weight* on the injured limb for fifteen to thirty minutes. It is noteworthy that, if the plaster spica has been thoroughly molded to the hip, pain is immediately and permanently relieved.

At the end of two months the patient returns to the hospital, the plaster is removed, and another roentgenogram is taken. If this shows bony union, as it has so far in every one of my series of cases except two in which the treatment had to be interrupted—in one on account of an acute cholecystitis and in the other because of the onset of a maniacal mental derangement—a short spica is applied and the patient is again discharged to home care, with instructions to walk for increasing periods several times each day, using crutches but *bearing weight* on the injured limb. The short spica is left on for a month to six weeks, and is then replaced by a

canvas corset spica for another month, after which no dressing is required. The second or short spica extends at first to the middle of the leg. Gradually this plaster is cut away, so that in a fortnight it extends only to the knee, allowing a gradual return of motion in this joint.

THE EFFECT OF EARLY WEIGHT-BEARING

1. On the patient's morale: We have up to now been compelled to announce to a patient with a fractured hip that he will be confined to bed for at least three months and very likely six months. This, naturally has been very depressing news not only to the patient but to the family. In many instances this period has been prolonged to nine months or even a year. With the employment of the system of treatment herein described, within a week the patient is out of bed, standing one or more times a day, and within two weeks or less he is walking across the room. This has a comforting and stimulating effect on the patient who appreciates that not only is he not doomed to prolonged and chronic invalidism but he is actually on the road to recovery.

2. On the nursing care of the patient: Through the teachings of Royal Whitman, we have for many years known how to care for a patient confined because of a fractured hip. When the plaster spica is properly applied, the patient is free from pain and can be turned on his face several times a day for cleansing of the skin. Thus bed sores are avoided. The change of posture also prevents hypostatic pulmonary congestion. Getting the patient out of bed affords even better opportunity to keep the skin intact and clean. The more radical change of posture improves breathing and even more certainly prevents pulmonary stasis. In addition, the repeated use of the blow bottles assures thorough aeration of the lungs. Incidentally it should be emphasized that, when a long plaster spica has been firmly applied, one nurse or an attendant can easily handle the patient, turn him from one position to another, and get him out of bed for walking. My assistant, Dr. Max Rabinowitz, has treated ten cases of fracture of the hip in the last two years by the ambulatory method. In many of them there was no need for professional nursing care, as he was able to instruct a member of the family in the essentials of nursing, thus reducing the economic burden which has always been a heavy one in the treatment of a fracture at the hip.

3. On the position and circulation of the fractured fragments: It is well known that in a truly impacted fracture of the neck of the femur healing by bony union progresses rapidly. I believe that weight-bearing causes an impaction of the fragments. With each step the fragments are forced into more intimate contact until they are locked. This secondary impaction not only secures the reduction but assures thorough vascularization of the fractured area through the blood supply from the distal neck fragment and the posterior portion of the joint capsule which, according to autopsy experience, is rarely torn. That there is actually an increased degree of contact or an impaction may be deduced from the observation that in

TABLE I

ANALYSIS OF TWENTY-FOUR CASES OF FRACTURE AT THE HIP
TREATED BY REDUCTION, IMMOBILIZATION, AND EARLY WEIGHT-BEARING

Case No.	Name	Sex	Age (*Years*)	Duration of Fracture at Time of Reduction	General Condition of Patient	Type of Fracture	Weight-Bearing Begun	Result	Remarks
1.	M. G.	Female	61	4 days	Good	Trans-cervical	4th day	Bony union	Firm healing in 3 months. At end of 5½ months the patient traveled long distances unaided.
2.	W. B.	Male	55	4 days	Good	Trans-cervical	4th day	Bony union	At end of 3 months walked 2 flights of steps without assistance.
3.	B. C.	Male	44	3 weeks	Good	Trans-cervical	3rd day	Bony union	Healed in 2 months. Patient returned to former work at end of 6 months.
4.	M. M.	Male	80		Poor	Trans-cervical	3rd day	Bony union	Healed in 2 months. Functional result is unusually good.
5.	M. R.	Male	62	Several days	Good	Trans-cervical	9th day. Hernia prevented walking.	Bony union	Had large bilateral inguinal hernia, preventing walking. Had apparatus for tapping limb to imitate walking. Healed in 2 months.
6.	S. H.	Male	65	9 days		Trans-cervical	8th day	Bony union	Healed in 2 months.
7.	M. H.	Female	88	3 weeks	Poor	Trans-cervical	7th day	Bony union	On admission, patient had severe pain, râles in chest, and sacral decubitus.
8.	M. B.	Male	64	1 day	Very poor	Trans-cervical	4th day	Bony union	Healed in 3 months.

TABLE I—(*Continued*)

Case No.	Name	Sex	Age (*Years*)	Duration of Fracture at Time of Reduction	General Condition of Patient	Type of Fracture	Weight-Bearing Begun	Result	Remarks
9.	J. K.	Female	65	2 days	Good	Trans-cervical		Bony union	Although the alignment was not perfect, there was enough end-to-end contact to insure union.
10.	L. R.	Female	66	1 day	Good	Trans-cervical	5th day	Bony union	Although she stood up on 5th day, she did not begin to walk until 3rd week. Has walked considerably since then.
11.	P. M.	Female	67	Several days	Poor	Trans-cervical		Non-union	Patient had had hemiplegia. Had acute mental derangement. Treatment interrupted.
12.	E. N.	Female	55	Several days	Good	Trans-cervical		Non-union	Patient developed acute cholecystitis, necessitating removal of large part of plaster and interruption of treatment.
13.	I. S.	Male	60	1 day	Fair	Inter-trochanteric	4th day	Bony union	Reduction under local anaesthesia. Very free motion at hip.
14.	E. P.	Female	95	5 days	Poor	Intertrochanteric, extensive comminution	10th day	Bony union	Had fracture of right elbow and extensive contusion of opposite lower limb. Fracture of right clavicle. Extensive laceration of right buttock and sacral area. Hip healed in 3 months.
15.	I. S.	Male	10	5 days	Good	Intertrochanteric	10th day	Bony union	Solid union in 2 months.

16.	B. S.	Female	60	4 weeks	Good	Intertrochanteric		Bony union	Shaft of femur fractured during manipulation.
17.	A. B.	Female	71	1 day	Good	Intertrochanteric	4th day	Bony union	Was out of bed on an average of 6 hours each day.
18.	R. P.	Female	62	5 days	Poor	Intertrochanteric	2nd day	Bony union	Healed in 2 months. Slight coxa vara.
19.	J. R.	Male	45	3 days	Fair	Intertrochanteric, comminuted	10th day	Bony union	Delay in getting patient out of bed because of injury to chest muscles and possible injury to head.
20.	L. L.	Female	69	2 days		Intertrochanteric	Stood 5th day, walked 3rd week	Bony union	Local anaesthesia. Some coxa vara.
21.	D. L.	Female	60	13 days	Very poor	Intertrochanteric	3rd week	Bony union	Standing and walking delayed because of diabetes, ketosis, and fibrillating heart. It was especially important for this patient to get out of bed, otherwise she might have developed bed sores and sepsis. Walked 1 month after reduction.
22.	M. G.	Female	60	2 days	Very poor	Intertrochanteric, comminuted	3rd day	Bony union	Patient had diabetes and myocarditis. Some coxa vara and separation of lesser trochanter resulted.
23.	B. F.	Female	66	1 day	Very poor	Intertrochanteric	3rd day	Bony union	General anaesthetic. Had had hemiplegia. Had been getting about holding on to objects.
24.	E. W.	Female	75	1 day	Very poor	Intertrochanteric		Bony union	Severe myocarditis, valvular disease, arteriosclerosis.

every case of a fracture through the neck of the femur in my series the late roentgenograms show that the femoral neck is shorter than it was directly after the reduction. This shortening has taken place without any appreciable lateral displacement of the fragments and is, therefore, the result of more intimate interlocking. The blood supply to the femoral head has, in my cases, been adequate, as seems evident from the fact that the density of the head, neck, and shaft of the femur has remained uniform,—that is, there has been a complete absence of any aseptic necrosis of the head seen so frequently in cases of non-union. As the blood supply from the ligamentum teres has only a limited distribution, the femoral head must, in my cases, have derived most of its nutrition through the blood vessels which enter it from the distal neck fragment and the joint capsule.

4. *On healing of the fracture:* In every one of my cases in which the treatment was carried on without interruption—in all but two patients—the healing took place as rapidly as elsewhere in the femur. There was bony union at the end of two months. I maintained immobilization by a short spica for another six weeks, probably through ultraconservatism rather than because of any urgent need for it. A number of my patients between sixty and seventy years of age were able to walk several flights of steps at the end of the fourth month. One patient (Case 1) went shopping alone in New York for an entire day five and one-half months after the occurrence of the fracture.

The average age of the patients with transcervical fractures was sixty-

TABLE II

REVIEW OF TWELVE CASES OF INTERTROCHANTERIC FRACTURE WITH REFERENCE TO ULTIMATE ANGLE BETWEEN NECK AND SHAFT OF FEMUR

Case No.	Name	Before Reduction (*Degrees*)	After Reduction (*Degrees*)	Ultimate Angle (*Degrees*)
13.	I. S.	130	150	134
14.	E. P.	115		130
15.	I. S.	145		145
16.	B. S.	120		110
17.	A. B.	115	150	150
18.	R. P.	110	150	110
19.	J. R.	120		115
20.	L. L.	120	130	115
21.	D. L.	115	135	115
22.	M. G.	133	123	105
23.	B. F.	115	130	130
24.	E. W.	130		130

four years plus, the youngest patient being forty-four, and the oldest eighty-eight; the average age of those with intertrochanteric fractures was sixty-one, the youngest patient being ten and the oldest ninety-five years. (See Table I.) The system of treatment herein described seems equally applicable at all ages. With very few exceptions, the general condition of most of my patients on admission to the hospital was very poor. In several instances the medical consultants advised me to let the patients die in peace. Had I failed to apply treatment, it is likely that many of the patients in this series would have died from pneumonia, exhaustion, bed sores with secondary sepsis, or some similar complication, for many of them had advanced degrees of diabetes, arteriosclerosis, myocarditis, or nephritis. Yet none of these grave systemic lesions interfered with the healing of the fracture.

In the use of early weight-bearing in the intertrochanteric and subtrochanteric fractures, the chief advantages are: (1) The patient is more comfortable than if he were continuously in bed; (2) the nursing care is simplified; and (3) pulmonary congestion is avoided. Much interest centers about the fact that in intertrochanteric fractures, although union occurs in practically 100 per cent. of the cases, there is often left a coxa vara which causes a limp and a variable disability. In six, or 50 per cent. of the twelve cases of intertrochanteric fracture herein reported (Table II), there was a residual mild or moderate coxa vara. In six of seven cases in which measurements were made in the immediate postoperative roentgenogram, the angle between the neck and the shaft was normal or better than normal, the average being 120 degrees; ultimately, however, this angle was maintained in only two cases. A further study shows that the angle was maintained in the original plaster, but was lost in the second plaster applied at the end of two months. In all but one instance, the second plasters were not applied by me and were much too loose, allowing a certain amount of give at the fracture line. I, therefore, conclude that to avoid an ultimate coxa vara in intertrochanteric fractures it is necessary to leave on the original spica for at least three months, or until there is solidification of the union. Should it be necessary to reapply a plaster spica sooner, the dressing should be accurately molded about the hip to maintain abduction and the required angle between the neck and shaft of the femur.

ANAESTHESIA IN THE AGED

Several of my colleagues have used novocain locally for the reduction of the fracture and so have eliminated the potential ill effects of a general anaesthetic. I prefer a general anaesthetic because it affords greater relaxation and better opportunity for accurate and rapid reduction. My average time for reduction of the fracture and application of a plaster spica is fifteen minutes. With a thoroughly organized team of assistants, ten minutes is probably enough. Any patient who cannot tolerate a fifteen-minute light anaesthesia of ethylene or of avertin, nitrous oxide, and

Fig. 1

Case 1. Transcervical fracture of the left hip.

Fig. 2

Case 1. Directly after reduction. Note the alignment of the fragments and the length of the femoral neck. There is moderate coxa valga.

oxygen will probably not survive at all. As a matter of fact, of the many patients with fractured hips whom I have treated in the last twenty-five years, not one has died either under anaesthesia or because of it.

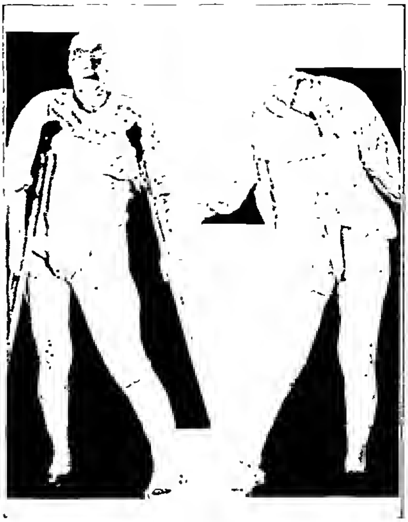

FIG. 3

Case 1. Patient walking freely with crutches every day.

REPORT OF ILLUSTRATIVE CASES

CASE 1. Mrs. M. G., sixty-one years old, was admitted to the Hospital for Joint Diseases on February 15, 1936, four days after injuring the left hip. She had severe pain in the left hip and total disability. She was markedly depressed, feeling that she was going to remain totally incapacitated and a burden to herself and to her family. The clinical and roentgenographic examinations (Fig. 1) showed a transcervical fracture. The fracture was reduced under a general anaesthetic. The postoperative roentgenogram (Fig. 2) showed an excellent alignment of the fragments. The pain was immediately relieved. The patient was taken out of bed on the fourth day and soon was walking about the hospital corridors with the aid of crutches (Fig. 3). Her depression disappeared and she became cheerful.

The long plaster spica was removed after two months, at which time clinical and roentgenographic evidence indicated healing of the fracture. A short spica was applied and walking was continued. The short spica was removed after one month. There was not only firm union clinically, but a roentgenogram (Fig. 4) showed osseous union of the fragments and bony lamellae, extending from the head into the neck. This roentgenogram shows

FIG. 4

Case 1. Three months after reduction. The fracture has healed. The neck is shorter than it was directly after reduction (Fig. 2) because of secondary impaction of fragments as a result of weight-bearing.

FIG. 5

Case 10. Transcervical fracture of the right hip.

the shortening of the neck due to secondary impaction resulting from weight-bearing. The density of the head is similar to that of the neck, indicating adequate vascularization across the fracture line.

The patient was provided with a laced canvas spica and a cane was substituted for the crutches. Five and one-half months after the injury she went shopping alone all day long, and, as she expressed it, walked "plenty". I examined her in October and found that not only was she quite independent of all assistance but that she had a more than adequate range of motion in the hip. She sat down in an ordinary chair and got up with ease. At the hip, extension was complete, and there was flexion to 140 degrees. She had 35 degrees of abduction and 25 degrees of adduction. Rotation was possible through half of the normal range. The lower limbs were of equal length.

CASE 10. L. R., female, sixty-six years old, sustained a transcervical fracture of the right hip (Fig. 5) on August 22, 1936. I saw her on the following day. The fracture was reduced and an ambulatory plaster spica was applied. The post-operative roentgenogram (Fig. 6) showed an excellent reduction. It is interesting to see the very thorough realignment in spite of the fact that the Leadbetter heel-palm test was negative after three

FIG. 6

FIG. 6.

Case 10. After reduction, showing excellent alignment and contact of the fragments. Note the comparatively long femoral neck.

attempts at reduction. This patient was unusually timid. Hence she did not stand up until the fifth or sixth postoperative day and did not really begin to walk until the third week. She then walked several times a day, usually going several times across her bedroom floor which was unusually large.

Nine weeks after the fracture, on October 26, 1936, clinical and roentgenographic examinations (Fig. 7) showed good alignment and bony union. The neck was moderately shortened, demonstrating the secondary impaction of the head onto the neck, a very wholesome effect. On December 15, 1936, sixteen weeks after the reduction, there was solid bony union. The patient walks with the aid of a cane.

Fig. 7

Case 10. Two months after reduction. The fracture has healed. The neck is shortened through secondary impaction of the fragments.

Case 17. A. B., female, seventy-one years old, was injured on August 3, 1936. She sustained an intertrochanteric fracture with marked separation of the fragments (Fig. 8). She was admitted to the Hospital for Joint Diseases on the following day. The fracture was reduced and an ambulatory plaster spica was applied. The postoperative roentgenogram showed excellent alignment of the fragments. The patient was taken out of bed on the fourth day and within a few days thereafter she was able to stand and to walk comfortably with crutches. She was then taken to her daughter's home.

Two months later the spica was removed and the clinical and roentgenographic examinations (Fig.

Fig. 8

Case 17. Intertrochanteric fracture of the left hip. Note the wide separation of the fragments.

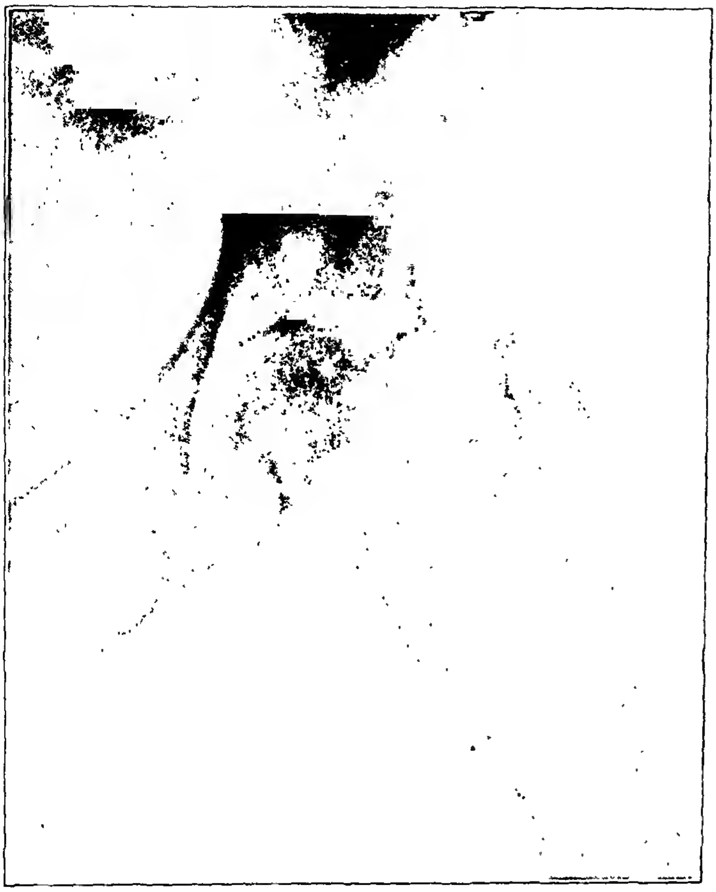

Fig. 9

Case 17. Two months after reduction. The fracture has healed, and the alignment of the fragments is satisfactory.

9) showed healing of the fracture. A short plaster spica was applied, and the patient left for her own home in California.

END RESULTS

This paper is based on an experience with twenty-four cases of fracture of the neck of the femur,—twelve transcervical and twelve intertrochanteric. Bony union was obtained in all but two cases in which an intercurrent illness interrupted and terminated the treatment within the first two weeks after the reduction. Solid bony union was obtained in twenty-two of the twenty-four cases within three months. In many of these cases, bony union was evident at the end of two months. External support through the use of crutches or a cane was continued for an average of five months. In none of the twenty-four cases was there any sign of aseptic necrosis of the femoral head. This experience is being duplicated by several of my associates who have been treating fractured hips by the method herein described. During the last two years, Dr. Max A. Rabinowitz, of Brooklyn, has treated ten cases of fracture of the neck of the femur—six subcapital and four intertrochanteric—by the procedure I have outlined and has obtained bony union in each case.

In addition to the cases herein included, I have treated several more by the method described, but have excluded them from this series for various reasons. Some are of too recent date. One woman in the late seventies died three days after the reduction from a cardiac attack. She had had many such attacks prior to the injury. Another woman of eighty-seven died three days after the reduction from a pulmonary embolism. Two service cases were accidentally discharged from the hospital too soon and cannot be traced. For the time being, I am concerned only with those patients in whom the treatment was carried out to completion.

I treated my first case according to the system described in February 1934 and made a preliminary report of the method in *The Journal of Bone and Joint Surgery* in October 1935. In the September 1936 issue of *Surgery, Gynecology and Obstetrics* there is an article on the "Ambulatory Treatment of Fractures of the Neck of the Femur" by Dr. George L. Apfelbach and Dr. Leon J. Aries of Chicago. Their method differs from the one I employ in only a few technical details. They, for instance, do not attempt a reduction of the fracture until five or six days after the injury. I can see no reason for such a delay except under extraordinary circumstances such as severe shock, hemorrhage, fracture of the skull with signs of intracranial pressure, etc. Certainly in the majority of cases, whether the patient is young or old, the sooner the fracture is set and immobilized, the sooner will the patient be relieved of pain and the resulting exhaustion.

SUMMARY

The results of the treatment by the system outlined have been so startling—in all cases in which the treatment was not interrupted by some intercurrent illness bony union was obtained—that they seem incredible in the light of our previous experiences. Perhaps it is merely good fortune in a small series of patients, but the facts that some of my colleagues who have used the method obtained equally good results, and that Dr. Apfelbach and Dr. Aries report a high percentage of bony union by a method which is practically identical with the one I use, encourage me to hope that accurate reduction, firm immobilization, and early weight-bearing will help solve the vexing problem of fracture of the hip.

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PATHOLOGICAL DISLOCATION OF THE SECOND TOE

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Pathological dislocation of the second toe is not a rare condition. In proof of this, the author wishes to report seven cases, five of which were treated at the Hospital for the Ruptured and Crippled in New York City. Four of the seven were seen during the last four months of 1936. The condition was first brought to the writer's attention by Dr. Raymond W. Lewis, Chief Roentgenologist of the Hospital for the Ruptured and Crippled. Only one case has been reported previously; this was described by Corrêa do Lago, Jr., as an unusual complication of hallux valgus.

This article will deal mainly with the cause of the deformity. The condition is becoming more common, because the high heels on women's shoes keep the toes in chronic hyperextension. There are definite reasons for pathological dislocation of the second toe instead of the other digits. Roentgenograms of two cases are shown in Figures 1 and 2.

FIG. 1

Case 3. Roentgenograms of the left foot, showing pathological dislocation of the second toe.

Fig. 2

Case 4. Roentgenograms of right foot, showing pathological dislocation of the second toe.

ETIOLOGY

Pathological dislocation of the second metatarsophalangeal joint is brought about over a period of months by a sequence of events that are so chronic that the deformity is apt to be unrecognized. The pain finally becomes so severe that the patient seeks medical treatment for her feet. The term "her feet" is used because all the cases thus far have been found in women, who wear high heels and walk with their toes in extension, which is the primary position for dislocation. There is no reason why pathological dislocation of the second toe should not occur in men if their toes are maintained in extension over a long period of time.

In order to explain the etiology of this deformity, it is necessary to give the essential anatomy and kinesiology of the human foot as found by dissection. The muscle distribution to the toes is not identical. The second toe has *two interossei dorsales* and no interosseous plantaris. The third and fourth toes have one of each of these muscles. The origin of each of the interossei dorsales is by two heads,—one from each meta-

tarsal between which the muscle is placed. The two interossei dorsales which control the second toe arise from the first and second metatarsals and from the second and third metatarsals, as shown in Figure 3.

Each muscle ends in a tendon just proximal to the metatarsophalangeal joint, which frays out over the dorsolateral or dorsomesial aspects of the base of the proximal phalanx. This tendon ends by fusing with the extensor tendons on the dorsum of the toe. So far, this coincides almost identically with the description in Gray's Anatomy. The function of these muscles is found to be the same as there described, provided that the toes are straight, but the function of abduction and adduction is changed when the first phalanx of the toe is in the extended position. By contracting first one and then the other of the interossei dorsales of the second toe, when that digit was extended, it was found that the base of the proximal phalanx was rotated dorsally, first on one side and then on the other. In conjunction with the normal extension force of the toe, there was a resultant line of pull which carried the base of that phalanx dorsally over the metatarsal head. This placed a strain upon the capsule of the joint, which, if continued over a long period of time, would stretch or tear the capsule and dislocate the toe.

Fig. 3

Dorsal view of the interossei dorsales muscles with the second toe in the claw position.

The two interossei dorsales of the second toe have dual innervations; the main supply is by the lateral plantar nerve from the tibial nerve, which is also distributed to the plantar flexor muscles of the foot. In addition, the first interosseous dorsalis frequently receives innervation from the medial branch of the deep peroneal nerve. The second interosseous dorsalis receives innervation from the lateral branch of the same nerve. The deep peroneal nerve is a branch of the common peroneal nerve which also supplies the extensor muscles of the foot. Thus it is possible for the two interossei dorsales of the second toe to contract when the foot is being flexed or extended. On walking, this would give a continual strain on the capsule of the metatarsophalangeal joint, provided that the toe was in sharp extension. The proximal phalanx is extended in the case of

high-heeled shoes, if there is a hammer-toe deformity, or if hallux valgus crowds the second toe over the dorsum of the big toe.

One other factor of importance is that the second toe is longer than any of the other digits. This is a direct cause of extension of the first phalanx, because of pressure from tight shoes or stockings.

Forces for Dislocation

To recapitulate, there are three sound anatomical and kinesiological reasons why the second toe should dislocate instead of its fellows:

1. The second toe is longer than its neighbor, and, therefore, is more subject to the pressure of tight stockings or shoes. Therefore, the

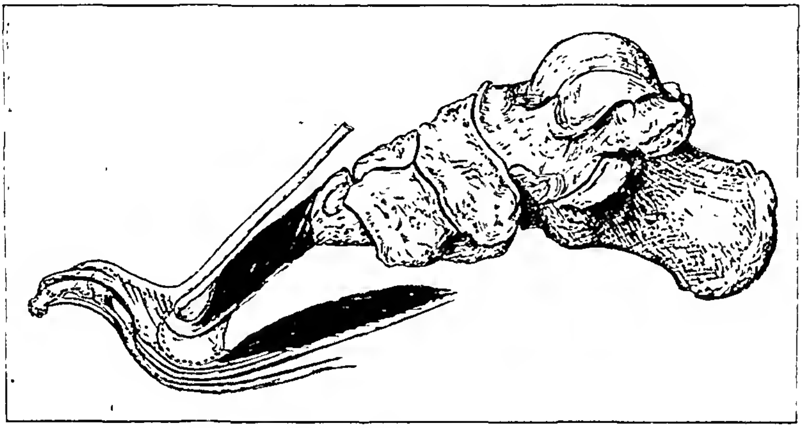

FIG. 4

Mesial view of the second toe with the first toe removed. The interossei dorsales and the lumbricales muscles are shown to illustrate their origins and insertions.

proximal phalanx, if not the whole toe, is more frequently held in hyper-extension.

2. The second toe has two interossei dorsales and no interosseous plantaris. In the hyperextended toe these two muscles give a dorsally luxating force aided by the two extensor muscles.

3. The innervation of the two interossei dorsales of the second toe, in many cases, is dual not only through the nerve supplying the foot flexors but also through the nerve supplying the foot extensors. Thus the interossei may continue their dorsally luxating force whether the foot is flexed or extended.

Forces against Dislocation

The lumbricalis would help prevent dislocation if the toe were straight. However, in hyperextension of the proximal phalanx the force of the first lumbricalis, as clearly shown by Figure 4. is exerted, at right angles around the metatarsal head, on the extensor tendon. This gives the effect of extending the distal phalanx and of pulling the base of the

proximal phalanx directly upon the metatarsal head. Therefore, the force of the muscle contraction is reversed and pulls forward on its origin from the long flexor tendon, thus weakening the flexion power of that muscle. The long and short flexors of the toe exert some flexion power on the proximal phalanx, even though it is hyperextended. However, most of the flexion is exerted on the two distal phalanges and increased flexion merely drives the proximal phalanx backward, forcing the toe into the "claw" deformity. When this state is reached, the "forces for dislocation" frequently become stronger and more effectual than the "forces against dislocation", with the resultant dorsal luxation of the toe.

SYMPTOMS AND CLINICAL FINDINGS

The chief complaint in these cases is pain. There is usually a history of painful feet over a long period of months or years. Invariably the patients localize the pain at the metatarsal region, and, on being questioned, they state that the second toe is the offender. In most cases a long history of hammer-toe exists. In some cases there is a history of bunions over a period of years, and the big toe bends laterally, forcing the second toe up over the first. Painful calluses are present. The pain gradually increases until the patient cannot work. Strapping of the feet and arches and non-operative treatments do not cure.

Examination usually reveals a severe hammer-toe deformity of the second toe, or this toe rides up over the other digits. There is a hollow space under the plantar surface of the base of the second toe that lies over the dorsum of the metatarsal head. There is swelling or thickening at the base of the second toe which is tender to palpation. Lateral movement of the toe causes pain. The toe cannot be plantar-flexed, due to pain and to shortening of the interossei dorsales and the extensors. Calluses on the dorsum of the toe are common findings. Local heat and discoloration are absent.

Diagnosis of dislocation of the second toe can be made by the history and clinical findings. Roentgenographic examination clinches the diagnosis. However, anteroposterior, lateral, and oblique films should always be taken.

TREATMENT

Treatments by strapping with adhesive tape, splints, and arch supports have failed in every case. Operative correction is necessary. The operator may use his own judgment and devise his own operation, but the one essential thing is that he must shorten the toe to allow secure and adequate reduction. The procedure used by the author is described in Case 1.

CASE REPORTS

CASE 1. (Patient of Dr. Philip D. Wilson, Hospital for the Ruptured and Crippled, New York City.) J. A., white, female, aged sixty-two years, was examined on September 20, 1935. She had had pain in the metatarsal arches for years. At times she

had been unable to walk because of the pain. Arch supports had given no relief. Dislocation of the second toe of the right foot was confirmed by roentgenograms, and an operation was performed on October 22, 1935.

Under general anaesthesia and tourniquet control, a dorsal incision was made over the second toe. The metatarsophalangeal joint was exposed and the base of the phalanx was found to be dislocated dorsally on the metatarsal. When the capsule was opened, the articular surface on the metatarsal head seemed entirely absent, and the bone presented an eburnated surface. The metatarsal was resected just behind the neck. This allowed the base of the phalanx to be replaced. The end of the metatarsal shaft was drilled, and the long extensor tendon of the second toe was divided and its end was passed through the drill hole and sutured to itself with silk. The wound was closed, and a soft dressing was applied, with no splint.

The postoperative course was uneventful, and there has been complete cure.

CASE 2. (Patient of Dr. T. Campbell Thompson, Hospital for the Ruptured and Crippled, New York City.) C. P., white, female, aged thirty-two years, was examined on September 9, 1936. There had been gradually increasing pain in the second toe of the left foot for eight months, associated with swelling, and the patient had been unable to work. Dislocation of the second toe was confirmed by roentgenograms. An operation was performed on September 11, 1936, under local anaesthesia, followed by complete cure.

CASE 3. C. K., white, female, aged thirty-eight years, was examined on November 6, 1936. She had suffered from hammer-toe for years. There had been increasing pain in the second toe of the left foot. Roentgenograms (Fig. 1) revealed dislocation of the toe. Operation has been deferred until the callus and ulcer on the dorsum of the toe shall have cleared up.

CASE 4. E. H., white, female, aged forty-two years, was examined on November 16, 1936. She gave a history of painful feet for months, with severe pain in the second toe of the right foot. Roentgenograms (Fig. 2) revealed dislocation of the second toe. Operation was refused.

CASE 5. E. B., white, female, aged seventy years, was examined on December 28, 1936. She gave a history of flat feet, bunions, and hammer toes over a period of years. The big toe of the right foot crowded the second toe up over the dorsum, causing severe pain. Roentgenograms revealed dorsal luxation of the second toe. Operation was refused.

CASE 6. (Patient of Dr. F. C. Kidner, Detroit, Michigan.) M. F., white, female, aged forty-two years, was examined on January 14, 1937. She had had weak feet, bunions, and hammer-toe for seventeen years. Diagnosis of luxation of the second toe of the right foot was made during routine examination for acute low-back pain. The patient refused operation until the low-back pain should be relieved.

CASE 7. (Patient of Dr. F. E. Curtis, Detroit, Michigan.) A. S., white, female, aged thirty-five years, was examined on March 19, 1931. There was a history of pain in the feet for months; this was localized to the metatarsal arches and was worse in the second toe. Dislocation of the second toe was confirmed by roentgenograms. Operation, in March 1931, resulted in complete cure.

CASE 8. K. D., female, aged sixty-five, was seen recently by the author. She had had painful feet for many years. Examination showed a pathological dislocation of the second toe of the left foot and corns over the second toe of both feet. These toes tipped upward and were very tender, especially that of the left foot. Only temporary relief was secured by strapping, and operation was advised.

SUMMARY

Pathological dislocation of the second toe is a definite deformity that has not been dealt with in the medical literature of the world. There

has been one case reported previously. This deformity is not a rare condition, and it is becoming more common. The etiology has been explained on an anatomical, kinesiological, and neurological basis by showing that the line of force of the contracting muscles is altered by chronic hyperextension of the proximal phalanx of the second toe. The musculature of the second toe is different from that of the other toes. This has proved to be a definite etiological factor in the production of the dislocation.

The author wishes to thank Dr. Philip D. Wilson and Dr. T. Campbell Thompson of New York City, and Dr. F. C. Kidner and Dr. F. E. Curtis of Detroit for permission to include their cases in this article.

REFERENCE

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BONE REGENERATION FOLLOWING MAGGOT THERAPY IN COMPOUND FRACTURES

A Newer and Simplified Method of Maggot Application in Cases Complicated by Severe Comminution or Large Osseous Defects

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The results of treatment in severely comminuted compound fractures with gross infection and those complicated by large osseous defects are at best only mediocre. All too frequently a primary amputation is done by a surgeon who, as a result of his experience, has come to believe in the comparative hopelessness of any other form of therapy. He has found that conservative treatment offers no guarantee of a functional cure and, in addition, wastes a great deal of the patient's time in a useless effort. Access to an adequate supply of maggots led us to use them in this particular type of case, as well as in those of a less serious nature.

That the beneficial action of maggots in infected wounds has been long recognized is shown by the comments of Ambroise Paré and Larrey. Baer's independent observation during the World War stimulated interest in their use, so that at the present time many clinics, hospitals, and practitioners are utilizing this form of treatment. In this Hospital, the work of Fine and Alexander on the cultivation and use of fly larvae led to their use in selected cases. Since in Charity Hospital all osteomyelitis is treated on the Surgical Services, there has been little opportunity to observe any modification of the course of this disease by maggots. Some of the compound fractures treated were complicated by the loss of bony tissue, but excellent regeneration followed maggot therapy; this observation seemed of sufficient general interest to report.

Pomeranz has recently reported a certain type of bone regeneration following the use of maggots. In general, our findings closely resemble his, even though the bone defects in this series were larger than his. We have been unable to find any other comments in the literature on this subject.

MATERIAL AND METHOD

The maggots used were grown according to the technique described by Fine and Alexander[2].

Fig. 1

Case 1. Roentgenogram following accident.

Fig. 2

Case 1. Eight weeks after injury.

Fig. 3

Case 1. Six months after injury.

A rather detailed description of our present technique of the preparation and treatment of the wound is warranted because of its great variance with that generally followed. If the laceration of the skin is of sufficient size, no further opening is necessary. In the case of infected gunshot fractures and those in which the skin opening is small, an incision is made in the superficial tissues, roughly comparable to the area of bony comminution. No débridement is done and no attempt is made to remove any bone fragments save those grossly detached. The aim is simply to provide adequate exposure of the infected or contaminated areas. If gross hemorrhage is present, the wound is packed with vaselin gauze for twenty-four hours. If iodoform or other strong chemicals are used, the implanted maggots are speedily killed. No antiseptics are used for cleansing the traumatized skin, muscle, or bone.

The surrounding skin is generally swabbed with ether and covered for from two to three inches about the wound with vaselin gauze. Vaselin is used to diminish skin irritation. Many other dressings and solutions have been used to protect the skin, but none have proved any more efficient. A thin layer of sterile gauze is placed in the depths of the wound, eliminating dead spaces where possible. Under aseptic precautions a massive dose (approximately 5000 in number, representing about one cubic centimeter of fly eggs) of twenty-four-hour-old maggots, two to three millimeters in length, is removed from the sterile bottle with gauze

and laid on the gauze covering in the bottom of the wound. A dressing of sterile gauze, from four to six inches in thickness, is then applied. The usual dose of maggots is from 500 to 1000, so that the massive dose used by us represents five to ten times that amount.

The maggots immediately enter the traumatized area in search of food. As long as devitalized tissue or pus is present, or until the maggots attain their full growth (twenty-four to forty-eight hours), they will remain in the depth of the wound and will not stray. No cage or other means of retaining the maggots in the wound is used.

In response to the action of the larvae, a copious amount of thin, dark-brown exudate pours from the wound and is absorbed by the thick dressing. It is, therefore, necessary to change the superficial layers of the gauze dressing covering the wound every six to eight hours; otherwise the maggots would drown in the wound. As has been noted, the maggots mature in from twenty-four to forty-eight hours. From this time on they no longer will feed to any extent, but simply crawl from place to place and eventually, within from four to six days, pupate.

Since the larvae are comparatively useless in a wound during this latter period, we have consistently removed them. This is accomplished by the removal of the entire gauze dressing at the end of forty-eight hours, for, when the maggots are fully fed, they migrate from the wound into its covering. Comparatively few remain. They, in turn, may be removed by the later change of dressings. Generally speaking, none remain at the end of seventy-two hours.

The complications of maggot treatment are, in our experience, few and not serious. The most annoying is the pain experienced by some patients. Since the period of habitation in the wound by the maggots is short, we have routinely ordered sedatives or, if necessary, hypnotics or even narcotics. Skin irritation, occasionally disagreeable, has not been completely controlled.

As a result of the action of the maggots, several changes in the wound are noted. In contaminated but not infected lacerations, no pus or, at the most, very little pus is noted, and fine, clean, pink granulations rapidly appear, especially in the recesses where accumulations of exudate generally are seen. Grossly infected wounds are cleansed of the dirty, heavy, gray granulations present, the discharge of the pus is diminished, and the odor is made much more pleasant. In this type of wound, maggot implantations are necessary usually at intervals of ten to fourteen days in contrast to intervals of fourteen to twenty-one days in the simple contaminated wounds. Occasionally, one single dose of maggots has been sufficient. In those compound fractures with severe comminution we have not found sequestrectomy necessary in any case. The maggots loosen all non-viable bone fragments, making their removal a simple matter during the routine dressings. We have never found it necessary in any case of this type to take a patient to the operating room save for a primary incision.

CASE REPORTS

The following four cases are illustrative:

CASE 1. A. P., a white male, seventy years of age, sustained a compound comminuted fracture of the tibia and fibula (Fig. 1). The patient was seen seventy-two hours after injury. A severe infection required extensive incision. Skeletal traction by a Kirschner wire inserted through the os calcis was used for reduction and fixation. Eleven days after injury, maggots were applied for forty-eight hours. At the daily dressings numerous bone fragments were removed, until about ten centimeters of tibia was gone (Fig. 2). Traction was maintained for eight weeks. A fenestrated cast was then applied. In three months' time, there was complete healing of the skin. Several changes of casts were made. At the end of six months, the patient was allowed to walk, using a molded socket brace. Check-up roentgenograms at this time showed a complete fill-in of the defect in the tibia, definitely following the line of periosteal enclosure. (See Figure 3.)

CASE 2. J. H., a colored male, aged twenty-eight, sustained a compound fracture of the right tibia and fibula at the junction of the lower and middle thirds (Fig. 4). He was seen twenty-four hours after injury. A prophylactic dose of mixed serum was given, a Steinmann pin was inserted through the os calcis, and traction was applied. Twelve days after admission, maggots were applied and removed in forty-eight hours. Ten days later, the second dose of maggots was applied and removed in forty-eight hours. The oedema had disappeared, and the infection had cleared. The third application of maggots was given one week later and removed in forty-eight hours.

Eight weeks after admission, the roentgenogram (Fig. 5) showed a marked loss of tibial substance. A long leg plaster cast was applied and the patient was discharged

FIG. 4

Case 2. Roentgenogram following accident.

FIG. 5

Case 2. Eight weeks after admission.

FIG. 6

Case 2. Nine months after injury.

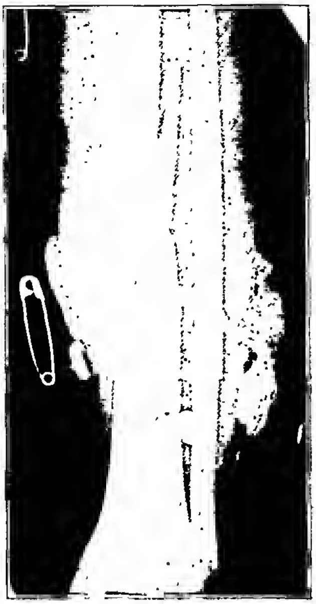

FIG. 7

Case 3. Roentgenogram following accident.

FIG. 8

Case 3. Seven weeks after injury.

FIG. 9

Case 3. Four months and one week after admission.

to the clinic. Nine months after injury, the roentgenogram was reported as showing "bony union in both bones and what appears to be a fusion of the callus between the tibia and fibula". (See Figure 6.) The patient was discharged, walking without support.

CASE 3. E. D., a colored male, thirty-three years of age, was shot in the left leg, causing a compound fracture of the tibia (Fig. 7). A few hours later, a "through and through" rubber-dam drain was inserted. A prophylactic dose of mixed serum was administered.

On the fourth day, a Steinmann pin was inserted in the os calcis, and traction was applied. The bullet wounds were enlarged and fifty cubic centimeters of gas-bacillus serum was given.

Three days later, maggots were applied for the first time and were removed after forty-eight hours. One week later, a fenestrated cast was applied. Eight days later, maggots were applied the second time for forty-eight hours.

Because of a marked soft-tissue infection, maggots were applied for forty-eight hours four times during the following month, and the cast was removed and replaced after each application. Roentgenographic examination (Fig. 8) showed that callus was present, but a section of the tibia, three and five-tenths centimeters in length, was missing.

Four months and one week after admission, the roentgenogram (Fig. 9) showed that the tibial defect was solidly filled in with callus.

CASE 4. O. O., a colored male, aged eighteen, was shot in the right thigh, causing a compound comminuted fracture of the femur. He was seen six weeks after the accident and examination showed marked infection, shortening of the femur of seven centimeters, and non-union (Fig. 10).

A Kirschner wire was put through the femoral condyles and traction was applied. Maggots were immediately applied and removed in forty-eight hours. Two large sequestrae (seven by two and five-tenths centimeters, and five by one centimeter) were lifted from the wound when the maggots were removed.

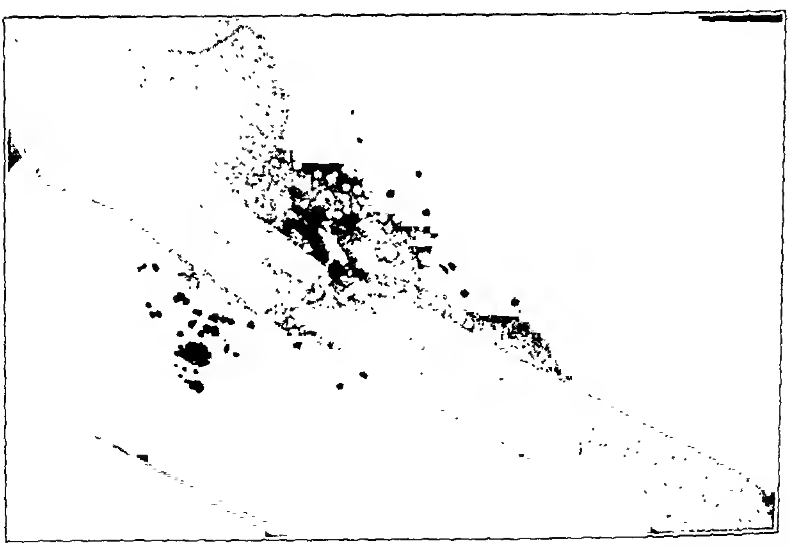

Fig. 10

Case 4. Roentgenogram six weeks after accident (on admission).

Fig. 11

Case 4. Eight weeks after accident (two weeks after admission).

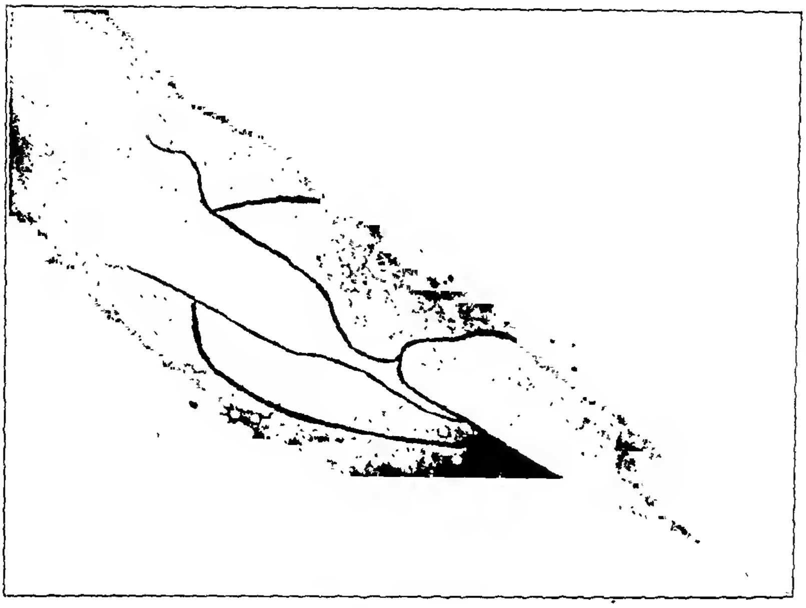

Fig. 12

Case 4. Five months after admission.

Twelve days later, there was no shortening of the extremity. (See Figure 11.) Maggots were applied the second time. Many lead fragments were removed when the thigh was dressed.

After eight weeks of traction, there was good callus across the seven-centimeter gap, and a fenestrated plaster hip spica was applied. Six weeks later, the hip spica was re-applied. In eight weeks the patient returned and the cast was removed. The report of the roentgenographic examination was as follows: "Anteroposterior and lateral views of the right femur, in which previous views had shown extensive bone loss, now show good bone regeneration with the fragments in good alignment." (See Figure 12.)

Five months after admission, the patient was discharged, walking on crutches as he was unable to buy a weight-relieving caliper. There was no shortening of the leg.

DISCUSSION

The cases reported represent a selection from approximately fifty-five compound fractures treated by the use of sterile maggots. We believe that these cases were readily handled by this form of treatment because of the excellent exposure. That the same results could have been obtained by any other method now in use is extremely doubtful. Previous experience with other forms of therapy has not yielded the same happy results. In all cases save Case 4 the bone regeneration took place apparently within the confines of the periosteum. In this one instance the fragmentation of tissue by the shotgun charge was undoubtedly the determining factor.

The part played by the maggots in these severe bone injuries is problematic. That the infection is rapidly controlled by them is incontrovertible. It is probable that the final result is obtained through a combination of mechanical and chemical action [9, 10] and the antiseptic properties of the intestinal ferments of the maggots [7, 8].

CONCLUSIONS

1. In certain types of compound comminuted fractures, the massive dose of maggots used (5000 or more) in a short period of time (forty-eight hours) controls infection and removes loose bone particles without secondary operations.
2. Extensive bone regeneration follows this type of maggot therapy.

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TREATMENT OF ACUTE BURSITIS BY NEEDLE IRRIGATION *

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Subdeltoid bursitis may be so painful as to require opiates and to render an upper extremity practically useless, and the disability may extend over a long period of time.

Rest, splinting, heat, diathermy, massage, and operative interference have thus far been the common forms of treatment. No one of these has been so uniformly successful that another form of treatment would not be welcomed by the profession.

Following out certain ideas and suggestions of Dr. M. N. Smith-Petersen, of Boston, during the past year at the Presbyterian Hospital in the City of New York we have treated sixty-three cases of subdeltoid bursitis by the irrigation method and have observed the facts mentioned in this paper.

SYMPTOMS

The patients were usually seen in the Emergency Ward and they complained of the ordinary symptoms of subdeltoid bursitis,—that is, pain in the shoulder, usually of acute onset, at first localized to the shoulder and then, depending on the duration of symptoms, extending over the entire shoulder region, even radiating down the arm to the region of the deltoid tubercle. The severity of the pain determined the amount of use in the arm. Some of the patients whose pain was of short duration (in several cases the duration was under twenty-four hours) were unable to take off their coats, to comb their hair, or to place their hands behind their backs. In the average case examination showed rather exquisite localized tenderness over the region of the subacromial bursa or over the supraspinatus tendon. There may or may not have been visible or palpable swelling in the same region. Except when the patient had been giving himself local heat therapy, there was rarely any evidence of redness or increased heat in the region of the shoulder. Two motions were always limited and painful,—namely, external rotation and abduction of the arm, actively or passively. In contradistinction to an intra-articular lesion, flexion and extension of the shoulder were usually not painful, if carefully done. Without exception, in each of the acute cases the patient carried the arm in a position of adduction and internal rotation with the forearm across the chest.

* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons, Cleveland, Ohio, January 13, 1937.

ROENTGENOGRAPHIC EXAMINATION

At first, in the carrying out of the irrigation treatment, it was thought that a roentgenographic examination was essential to complete the diagnosis. However, after a short time, it was found that the roentgenogram might show calcium deposits, which was helpful, but as a rule it did not mean much. This statement is made for the reason that in several cases the roentgenograms (which were always taken in two positions,—internal rotation and as much external rotation as possible) failed to show any evidence of increased density in the region of the bursa, and, upon irrigation of the bursa, calciumlike material was obtained and was proved by chemical examination to be the same as that removed at operation from patients with chronic bursitis with calcification. Also, in several cases in which the patients were given the diagnosis of subacromial bursitis of several weeks' and even of several months' standing, the roentgenograms failed to show any deposits of calcium, and, upon irrigation, a gelatinous, synovial type of fluid was washed through, which, upon examination, showed the calcium and ordinary constituents of the bursa as described by Codman. Therefore, roentgenograms were taken as a routine, but they did not alter the treatment based on the clinical findings.

RELATION TO INFECTION

In the clinical quizzing of these patients an attempt was made to find out if there was any possible relationship between bursitis and a previous or present infection in the body. From a review of the past histories and examinations we can feel fairly certain that bursitis is not associated with any past or present systemic infection. Many of the patients had a white blood count of 14,000 with a percentage of polymorphonuclear leukocytes as high as 75. Some of them ran a temperature of 101 degrees by mouth. However, in not one single case was purulent material (cultures positive) obtained from the bursa on irrigation, and in not one case was there any evidence of infection after irrigation. Weeks states that in most of his cases some history of an upper respiratory infection preceded the onset of the shoulder symptoms.

METHOD OF IRRIGATION

Equipment

The equipment consists of the following: two 18-gage steel needles, two and one-half inches long; one 20-cubic-centimeter syringe; sixty cubic centimeters of 1-per-cent. novocain; a hypodermic needle; one No. 10 Bard-Parker blade; and as much saline as thought necessary (usually about sixty cubic centimeters).

Technique

With the patient lying on his back, the affected shoulder is prepared with iodine and alcohol. Then, with the hypodermic needle and novocain,

FIG. 1

Position of needles in subacromial bursa. Note the relation of the anterior needle to the coracoid process of the scapula.

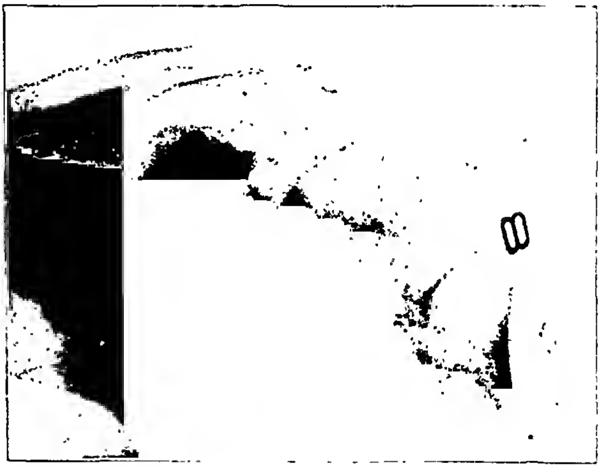

FIG. 2

Same shoulder as in Fig. 1, after the bursa had been irrigated.

a small wheal is made in the skin over the point of maximum tenderness. This point usually corresponds to a spot about one inch lateral to and on the same horizontal line with the coracoid process of the scapula. Then, with the point of the scalpel, the skin is nicked through the epidermis. In like manner, a second point is infiltrated just about one-quarter of an inch posterior to the greater tuberosity of the humerus on a level with the superior facet.

Following the injection of the novocain, one of the large needles is introduced through the skin incision in the anterior portion of the anaesthetized region. The point of the needle is directed posteriorly and upward toward the under surface of the acromial process of the scapula. The needle is then pushed deeper and, after it has reached a depth of from one-half to three-quarters of an inch, the wall of the bursa can be felt as a definite resistance, provided that the syringe is held between the index finger and the thumb. A quick stab places the needle point within the bursa. At times, a cloudy fluid may push the plunger of the syringe back, due to the increased tension in the bursa. Following the placing of this anterior needle, a second one is inserted into the region just posterior to the greater tuberosity, about one fingerbreadth below the acromioclavicular joint. The needle is pushed gently down to the superior facet of the greater tuberosity and actual bone is felt with the

tip of the needle. Then the needle is slowly withdrawn for about one-eighth of an inch and the tip of the needle is pointed in the direction of the assumed position of the tip of the anterior needle which is in the bursa. After this needle has been inserted for about one-half of an inch, the bursa is entered. Two cubic centimeters of novocain is used in each of the needles on the way down to the bursa and on going through the bursal sac.

As soon as the two needles are in place, the syringe is filled with normal salt solution and this is pushed through one needle to flow out the other. A material of the consistency of toothpaste, either homogeneous in appearance or crystal-like, may exude. At times it is so thick that it almost stops up the needle, and considerable force is required to push it through. With the 20-cubic-centimeter syringe full of saline, it is possible to force the solution out the other needle for a distance of twenty-one inches beyond its hilt. This can only occur when all the calcium has been washed out and the two needles are in perfect position. At this stage, there seems to be only one advantage in having calcium show in the fluid on washing,—it makes one absolutely certain that the needles are in proper position and the bursa is being washed as clean as possible.

Usually, as soon as one syringe of salt solution has been pushed through, the patient states that the acute pain has disappeared. The amount of saline used to wash the bursa clean varies from thirty cubic centimeters to sixty cubic centimeters. The needles are then withdrawn and a small sterile dressing is applied to the region of the shoulder. Following this, the patient can usually move the arm freely in all directions without pain. At first he is reluctant to do so, because he has had so much discomfort; this is especially true in the acute cases. Gentle passive manipulation can be done without harm and with actual benefit in cases of long standing. Often a definite give to the shoulder can be felt.

It is important to remember that in the use of the irrigation method as little salt solution as possible should be allowed to exude into the surrounding tissues. If this is prevented, on the following day the patient's arm will not be sore as if a hypodermoclysis had been given in the arm. He is better able to use the arm and to return to work more quickly.

In certain very sensitive individuals it is advisable to use gas-oxygen anaesthesia instead of local anaesthesia. Some of these patients have had so much pain that they cannot stand any procedure on the shoulder during the acute stage unless they are asleep.

TREATMENT FOLLOWING IRRIGATION

Immediately following the irrigation, the first of our patients were kept in the over-night ward; in each case the arm was suspended in a position of abduction and external rotation, and heat was applied in the form of thermolight. Early motion was requested. On the next day the arm might be sore when the patient attempted to move it in extremes of motion, but the original acute pain had disappeared. The patient was seen in the Clinic on the succeeding days. However, after the technique

had been improved, we discontinued this postirrigation treatment. The arm was placed in a sling and, if the patient was of the stoical type, he was allowed to go home and told to use the arm and move it only when he felt like it. No haste was made, with the result that on about the fourth to the sixth day the patient had full use of the arm without pain. Some of the patients had symptoms as long as nineteen days, but they could use their arms and sleep after the irrigation. We think now that, when a patient has had acute pain for a few days and, consequently, has been unable to sleep and is irritable, nervous, and worried, it is best to keep him in the hospital for a day or so. The irrigation can be carried out in the office, but we do not recommend it. Although we have not had an infection in any of these cases, there is always that possibility and we feel sure that there is less chance that anything may go wrong in the hospital than in the office.

DURATION OF DISABILITY

One of our primary reasons for writing this paper is to show that at present we have a form of treatment for acute subacromial bursitis that does not entail the period of economic disability common to the other forms of treatment. Codman states in his book that these patients are sure of being cured by operation and that, following the operation, the average period before symptoms subside and the patients are able to return to work is between two and six weeks. Since in the irrigation treatment the period of disability is less than a week, its importance can be seen. Furthermore, there have been no recurrences of symptoms in the acute cases in which irrigation has been properly carried out, and we have many cases which have been followed over thirteen months.

TABLE I

Summary of Cases Treated by Irrigation

Treated by irrigation		63 cases
Acute (7 days or under)	48 cases	
Subacute (under 1 month)	8 cases	
Chronic (over 1 month)	7 cases	
Histories of previous attacks		17 cases
Roentgenograms showed calcium shadows		48 cases
Average period of economic disability:		
Acute		4.8 days
Subacute		7.0 days
Chronic (when relieved)		10 – 14 days
Results:		
Complete relief of symptoms		57 cases
Infections		0 cases
Limited motion in shoulder		2 cases
Operation necessary after irrigation		2 cases
Pain and limited motion still present		2 cases

Note: Only one of the six cases included in the last three groups was acute.

SELECTION OF CASES

Not every patient with bursitis was immediately subjected to irrigation upon entering the Hospital. In addition to the sixty-three cases treated by the irrigation method, there were, during the year 1935 to 1936, 105 other cases treated by various methods. At first irrigation was done in every case, but later we learned which cases would respond best to this treatment. The other cases were treated either by physiotherapy in the form of diathermy and static brush or by operation. We found that irrigation was most successful in the following types of cases:

1. Very acute cases without history of previous attacks.
2. Cases in which the calcium, as seen in the roentgenogram, was fuzzy—not dense, round, or bonelike—and gave the appearance of not being in the tendon of the supraspinatus muscle.
3. Cases in which the acute pain was localized to one spot and did not radiate.

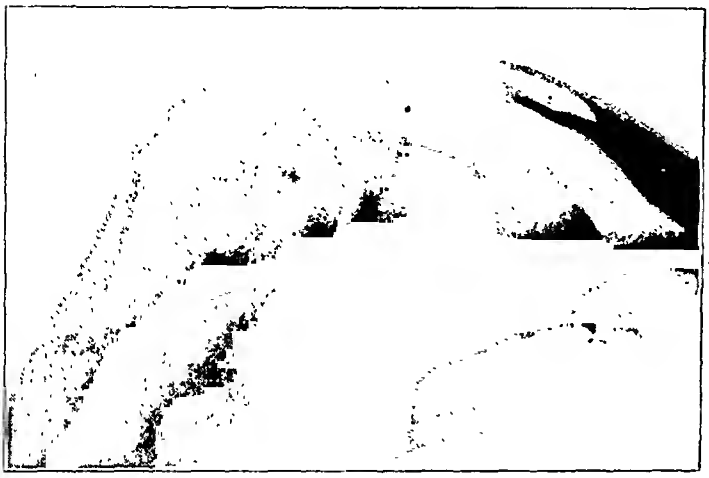

FIG. 3

This demonstrates the necessity for more than one view. With the arm in partial external rotation, there is increased density in the anterior region of the head of the humerus. This is very easily overlooked. (See Fig. 4.)

FIG. 4

With the arm in internal rotation, a dense, elongated calcium shadow can be seen. This is incompletely visualized with the arm in external rotation.

Taking as criteria immediate complete relief of pain and the length of time before the patients returned to work, the most successful results were obtained in cases of very acute nature with symptoms of only a few hours' or a few days' duration. The patients who enter, holding the arm by the side, begging for relief, not wishing even to be examined, and stating that, while combing the hair a few hours previously, they suddenly had had pain in the shoulder and since then have not been able to move the arm or to touch the shoulder, we feel sure will respond well

to this irrigation. Not all of the cases in this series were of this sudden onset as can be seen from Table I. We can say positively that certain of the cases diagnosed as chronic bursitis, in which an ache of long duration was present in the shoulder, and in which there had been occasional flare-ups, were relieved by the irrigation method, as shown by the following case.

Fig. 5

A dense calcium shadow is seen in the region of the supraspinatus tendon. Attempted irrigation failed and an additional roentgenogram was taken. (See Fig. 6.)

A woman, fifty-five years old, had had the subacromial bursa removed from the left shoulder two years before entering the Hospital. For fourteen months prior to admission she had had a constant ache in the right shoulder, which became worse at night, and it had been necessary to place a pillow under the elbow in order that she might sleep. Local heat, massage, and diathermy had failed to give her any relief. The bursa was irrigated and a clear fluid, as described in the early part of this article, was washed out. The patient was immediately free from symptoms, and slept well the first night. Suddenly, at the end of ten days, she again had acute pain in the shoulder. A second irrigation was done, and, for the past eight months, she has been asymptomatic. Roentgenograms in this case were negative.

Fig. 6

With the humerus forced into external rotation, definite calcification is seen in the subacromial bursa. Irrigation was again done, a good flow was obtained, and complete relief followed.

After a number of these cases had been studied, the rule was adopted that, when a patient entered the Emergency Ward with a history of pain and discomfort of long duration, he was to be sent to the Physiotherapy Department for diathermy, massage, and baking. If at the end of a reasonable period of time (approximately six weeks), he was still having difficulty, then irrigation was to be done. Some of these patients showed improvement and some of them did not. Operation was then resorted to in the unrelieved cases.

As a general rule, the absence or presence of calcium in the roentgenogram does not make much difference. However, those cases in which roentgenographic examination shows the presence of calcium of a decreased density and fuzzy appearance, apparently generalized throughout the bursa and not localized in the supraspinatus tendon, belong to the group that respond better to the irrigation method. If from the roentgenographic appearance the calcium deposits are hard, smooth in outline, of markedly increased density, and apparently in the tendon of the supraspinatus muscle, we have learned that irrigation, even under the fluoroscope and with the attempt to break up the deposits with the point of the needle, does not seem to have any effect. Therefore, these cases are considered surgical.

In two of our cases the calcium shadow in the roentgenogram was soft in appearance in some spots and in others appeared to be hard and bonelike. Irrigation was done and in neither case was there any relief from the acute pain, even though the soft calcium was washed out. Both patients had histories of previous attacks. Within a few days after the irrigation, they were operated upon and the bursae and tendons were examined. In each case the bursa was found to be slightly reddened but clean except for an occasional piece of the soft calcium material in the lining of the wall. An elevation in the floor of the bursa showed a deposit in the tendon of the supraspinatus. When the tendon was incised there was a puffing out of the toothpaste-like material as though it were under pressure in the tendon. Both patients obtained complete relief after the operation. This small amount of calcium flakes in the bursa is often seen in the roentgenograms taken after irrigation. We have many cases in which there is present apparently the same amount of calcium after the washing as before and yet, following the irrigation, the patients are entirely asymptomatic.

When the calcium deposits are felt with the tip of the needle to be hard and rocklike and the roentgenographic appearance is similar to that just described, we feel fairly sure that radical excision, rather than irrigation, should have been the method of choice.

When the patient enters complaining of acute pain in the shoulder, localized to one spot, and when, upon examination, there is a definite localized area of tenderness, then we immediately feel more confident of the result than if there is a generalized distribution of pain. In the cases in which the pain was of more than a few days' duration and had become of a radiating nature, there seemed to be one spot to which this radiation extended,—namely, the region of the deltoid tubercle. It is true that later the pain may go up the side of the neck and down the arm to the finger tips. If, after a week or so following the irrigation, the patient has an occasional twitch in the shoulder or any discomfort on extremes of motion, he will usually state that the difficulty is in the region of the deltoid tubercle. In one case in which the patient complained of pain in the region of the tubercle only, the roentgenogram revealed calcification in the supraspinatus tendon. A needle was placed in the bursa, with the

use of novocain in the skin only. This procedure was done under the fluoroscope. When the point of the needle was seen to touch the deposit and the tendon of the supraspinatus was felt to move with it, the patient immediately cried with pain referable only to the region of the deltoid tubercle. Into the deposit was injected two-thirds of a cubic centimeter of novocain, and the pain immediately disappeared. Two hours later the patient again complained of pain in the region of the deltoid tubercle. The significance of this pain distribution we are at present unable to account for.

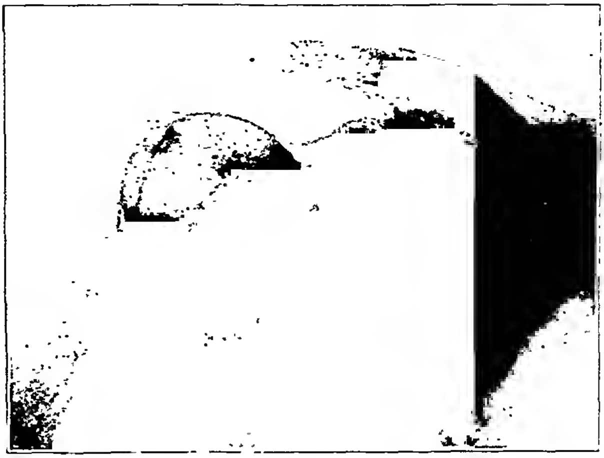

Fig. 7

A soft, homogeneous calcium shadow is dispersed throughout the bursal sac. This type of case responds exceptionally well to the irrigation treatment.

This irrigation method has been tried in several other cases of chronic subdeltoid bursitis, which have not been recorded in this series. Some of the patients have been relieved and others have not. The throbbing ache of which some of them complained has been relieved by irrigation and the outlook has been good, but the follow-up examinations show that these patients still have limitation of motion and occasional aches. At present, we cannot recommend simple irrigation for the cases of many years' duration in which the roentgenograms show no evidence of calcification. That the irrigation actually did help a few of the chronic cases cannot be overlooked, but, until we know more of the actual results of the treatment, it is probably better to limit irrigation to the acute and subacute cases.

We have also irrigated several bursae other than that of the shoulder—the subtrochanteric bursa, the semimembranosus bursa, the subscapularis bursa, and the olecranon bursa—and have obtained good results. In acute bursitis in any of these regions we recommend irrigation and can promise excellent results provided that a good flow is obtained through the two needles.

SUMMARY

1. Sixty-three cases of subdeltoid bursitis were treated by the simple irrigation method.

2. The results, evaluated on the basis of relief of the acute pain and on getting the patients back to work earlier than with any other form of treatment, seem to warrant its use.

3. The average period of economic disability following the irrigation is 4.8 days in the acute cases. There have been very few recurrences of

symptoms in the acute cases (some of the cases have been followed for over thirteen months).

4. Irrigation is not desirable in cases in which the roentgenograms show old calcification with a hard, bonelike appearance, probably in the supraspinatus tendon. To show calcium, roentgenograms should be taken in as much internal and external rotation as possible.

5. Irrigation did no harm in any of our cases; it may, therefore, be tried in any case, but it is recommended primarily for the acute cases with localized signs and symptoms.

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CLINICAL EVALUATION OF COLLOIDAL SULPHUR IN THE TREATMENT OF ARTHRITIS

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The importance of this problem has been reported in the recent survey of chronic diseases in Massachusetts, which revealed a greater incidence of rheumatism than of heart disease, tuberculosis, and cancer combined. In the Veterans' Administration, as well as in general life, this is an important factor.

The development of biochemistry and research work in colloidal chemistry has demonstrated the importance of the sulphur molecule as a protective mechanism against intoxication. Colloidal-sulphur therapy, therefore, has opened an avenue which promises to lead to more permanent results than have been obtained heretofore.

It is desired to emphasize the necessity for collaboration between the clinician and the biochemist on the one hand and the bacteriologist and pathologist on the other, the present position being not one of divorce, but of disengagement.

A number of published articles apparently were subjected to some criticism, as a parallel study with colloidal sulphur and other medication had not been made. The colloidal-sulphur régime in the treatment of arthritis was introduced by the writer at the Veterans' Administration Hospital, Bronx, New York, in 1932. These patients under observation had been treated for a number of years with vaccines and other antirheumatic medications, including special dietary measures. The results were not very satisfactory until the administration of colloidal sulphur was instituted in sufficiently large doses. We were primarily interested in obtaining relief and in reducing the economic loss created by this disease.

SULPHUR THERAPY

Colloidal sulphur, as originally used, was supplied in two forms: two-cubic-centimeter ampules, containing twenty milligrams of colloidal sulphur in acid-free olive oil, for intramuscular administration; and five-cubic-centimeter ampules, containing thirty milligrams of colloidal sulphur in aqueous solution of dextrose, for intravenous administration. Originally, a dose of ten milligrams of colloidal sulphur was administered intravenously, but it was found that the larger doses—thirty-milligram or five-cubic-centimeter doses—gave a better response and there were no untoward results or systemic reactions. In cases of severe type and of long standing, with low cystine content of the finger nails and a high sedimentation rate, thirty milligrams of colloidal sulphur was given every day until a course of ten injections had been administered. More satisfactory results were obtained from the intravenous administration, and the in-

tragluteal injections are now given only to patients in cases where it is impossible to penetrate the vein.

In the majority of cases (over 78 per cent.), the patients were free from pain after the fifth or sixth injection, and the spasticity of the muscles began to disappear. The effusion in the joints gradually became less, and, after about three or four weeks of treatment, it was practically gone.

When giving colloidal sulphur intravenously, great care should be taken to disperse it slowly and to prevent any leakage into the soft tissue, as the latter causes excruciating pain and sometimes sloughing of the soft parts at the vicinity of the point of injection. There is no evidence of any toxicity or other ill effects resulting from the proper administration of colloidal sulphur.

The patients treated received from two to three courses of colloidal sulphur of ten injections in each course, with the exception of the patients with muscular rheumatism, who received only one course. The average duration of treatment was ninety days.

SULPHUR COMPLEXES AS OUR PROTECTIVE MECHANISM

It is not amiss to state at this time that the part played by disordered metabolism in the production of atrophic arthritis has not received the attention it warrants. Considering that arthritis is a metabolic disturbance, superimposed by infection or some other unknown factor, it becomes necessary to deal with the changes in the process of oxidation, reduction, and impaired compensation. One of the most important facts is the change in the protein metabolism, involving increased formation of amino compounds. As an example, histamine, which is highly toxic, has definite physiological action and is one of the most important of the group. Normally, it combines with the loosely bound sulphur molecule and is eliminated. Pyman states that the potent physiological base as histamine loses its physiological activity when combined with sulphur.

It is a well-known fact that indole is oxidized to indoxyl when combined with sulphur, and is eliminated as indican. It is apparent that the loosely bound sulphur molecule plays an important rôle in the body activities as a part of our protective mechanism against toxins produced in the body.

This loosely bound sulphur in the form of glutathione and its products, cystine and cysteine, are the normal available substances furnished by the liver, and are the necessary constituents of the tissue cells. The evidence to date shows that glutathione plays an important part in the cellular respiration, oxidation, and reduction, which stimulate enzymatic activities. Cystine is present in definite quantities in the skin, hair, and nails. Du Vigneaud found a high cystine value in insulin. Sullivan and Smith found close parallelism between the loosely bound sulphur and the active principle of the posterior pituitary body. Sullivan and Hess reported cystine in a large number of vitamins, enzymes, and some other hormones.

It has been previously reported that, in the majority of arthritic cases, the low cystine content of the finger nails points toward an intoxication factor which utilizes sulphur complexes and thus diverts the cystine sulphur from the finger nails. The increase of cystine in the nails of arthritics after the injection of colloidal sulphur indicates that sulphur compounds, directly or indirectly, combine with the injurious material.

Sullivan and Hess reported that 65 per cent. of arthritic patients have an average cystine content of 9.08 per cent. in their finger nails, while the normal cystine is never below 11 per cent., and should be about 12.5 per cent. This work was substantiated by Neligan and Salt of England. Meyer-Bisch, in 1922, stressed the importance of sulphur metabolism in general body activities. Recently, numerous clinical reports on the value of colloidal-sulphur therapy in the treatment of arthritis have been published. In 1934 and 1935, the writer reported the results on 250 cases. Seventy-eight per cent. of these patients responded favorably to the treatment. Since the last report, we have had under treatment 106 more cases, showing equally good results, making a total of 356 cases treated. Senturia, Wheeldon, Rawls, and others have also reported favorably on the same subject.

In selecting cases for this treatment, it is necessary to take into consideration that colloidal-sulphur therapy will not restore injured and broken-down joints, nor will it correct deformities. These can be accomplished only by the institution of proper orthopaedic measures. Experience has shown that administration of colloidal sulphur will arrest further progress of the disease, relieve the patient of pain, reduce the spasticity of the musculature, decrease the effusions in the affected joints, and promote the restoration of the individual to a state of economic usefulness. The treatment is of equal value in chronic and acute cases as long as pain, swelling, effusion, and spasticity of the muscles are present.

CONCLUSIONS

1. The author is quite aware of the hypothetical character of some of the views expressed, but there must be imagination and play of ideas at the root of progress in science. It would seem that the views as to the nature of this disease must become more catholic. Following further clinical observation, it is felt that slowly but steadily a better and more complete understanding of this problem will be reached.

2. It is believed that arthritis is a metabolic disorder, superimposed by infection or some other unknown factor, causing a break in compensation.

3. The early administration of colloidal sulphur in cases of acute and chronic arthritis is of importance in order to prevent unnecessary suffering, prolonged invalidism, and deformities.

4. Our studies point to the restoration of metabolic stability as a necessary aim in treatment of arthritis.

5. It is the opinion of the writer that colloidal sulphur assists in restoration of metabolic stability.

6. The experience with 356 cases treated over the past five years warrants the conclusion that colloidal-sulphur therapy is of great value in the treatment of this malady.

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A PECULIAR SYSTEMIC DISEASE OF THE SPINAL COLUMN (PLATYSPONDYLIA AORTOSCLEROTICA)

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This paper is concerned with a peculiar disease of the vertebral column which we have not found described, and which seems not to be very common, for six cases only have been observed by us in the course of five years; nevertheless, the findings are so definite and distinctive that they seem to warrant the following report.

Clinical signs and symptoms are not characteristic and may even be absent. Occasionally there is some complaint of pain in the back and of being easily fatigued. Three patients noticed that they had grown a little shorter in stature during the preceding two or three years. In two of these cases, the gradual formation of a gibbosity was observed by the patients themselves or by members of their families. The youngest patient in our series was fifty-two years of age; the oldest, seventy-six. Two of them were males and four were females. Four were Orientals, one was a Russian, and one an Anglo-Saxon. One was a merchant, two were housewives, and three were employed in offices. Except for the two cases in which a gibbosity had formed, the condition of the spine was discovered accidentally during roentgenographic examinations of the chest and abdomen, as examination of the spine had not been asked for by the clinicians. This shows how slight or indefinite were the clinical symptoms induced by the disease,—a fact which contrasts strongly with the very pronounced changes shown on roentgenographic examination.

The roentgenographic findings are as follows:

1. Generalized demineralization of the whole spinal column, without similar decalcification of other parts of the skeleton.
2. Flattening of the bodies of a number of vertebrae, with concavity of their upper and lower borders.
3. Marked widening of the intervertebral spaces, which appear rounded because of the concave borders above and below them.
4. Extensive calcification of the aorta, both in the thoracic and in the abdominal portions.

It is evident that we have to do here with a morbid entity, characterized by a high degree of sclerotic calcification of the whole aorta, together with a systemic disease of the vertebral column, marked by softening of the bodies of a variable number of vertebrae. The intervertebral discs are not involved, at least not primarily, but they expand and encroach upon the space originally occupied by the adjacent and now softened bones. No signs are found of any such bony hypertrophic reactions as occur in almost all inflammatory affections of the spine; furthermore,

there is no evidence of arthritis in the apophyseal articulations. On the other hand, slight calcifications in the longitudinal ligaments are to be seen occasionally. Accordingly, we may conclude that this disease falls, nosologically, into that group of rare conditions in which the leading sign is widening of the intervertebral spaces.

Much roentgenographic evidence has accumulated in recent years as to the reciprocal relations subsisting between the intervertebral discs and the adjacent vertebral bodies. Building upon the foundations laid by Schmorl and his pupils, Keyes and Compere, Norlén, Calvé, Galland, Geist, Moffat, Wagoner

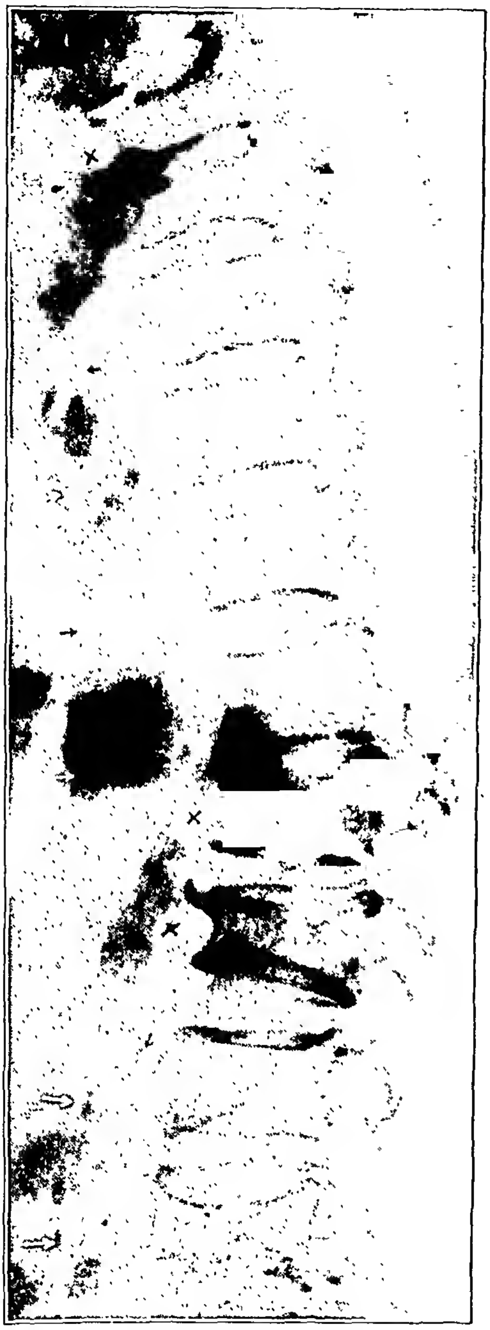

Fig. 1

Typical aspect in an advanced case, showing compression of the midthoracic and upper lumbar vertebrae (x) and extensive aortic calcification (arrows). The cervical and upper thoracic portions of the spine were normal; the lower thoracic vertebrae show very slight change.

Fig. 2

The lumbar spine, showing pronounced aortic calcification. Note that the upper lumbar vertebrae (x) are more affected than the lower.

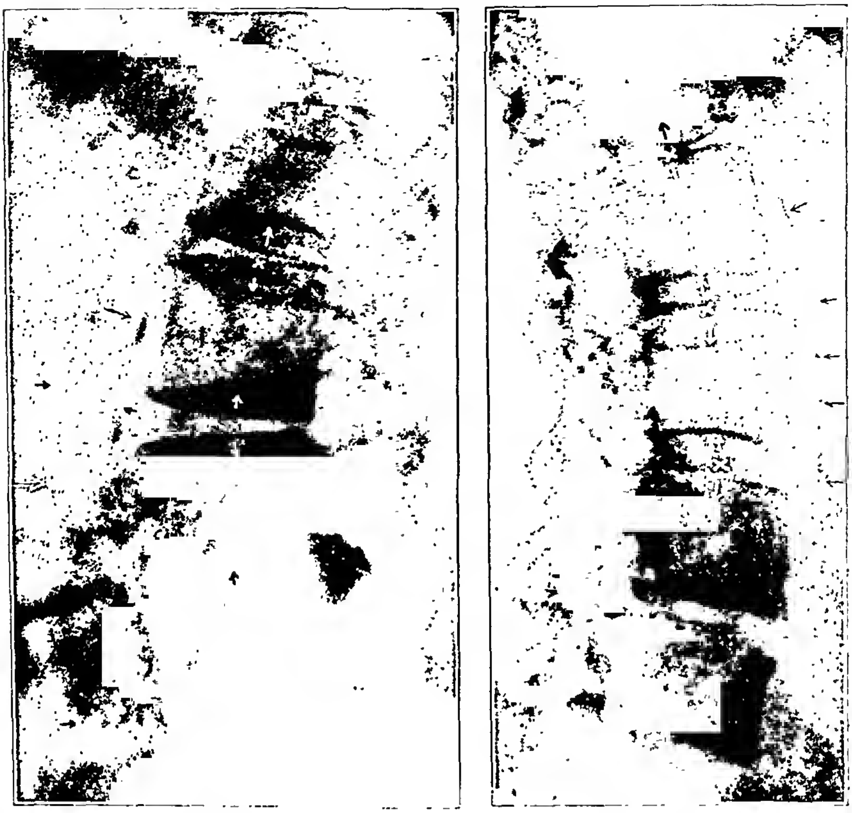

FIG. 3-A FIG. 3-B

Early stages of the disease in the lumbar spines of two patients. Note the similarity of the findings. The upper vertebrae are more affected; the intervertebral spaces are wider than those below. The arrows denote moderate aortic calcification. Similar changes were present in the midthoracic spine.

and Pendergrass, Smith, Turner, Oppenheimer, and others have shown that the elasticity and the hardness, respectively, of discs and of vertebral bodies are important factors in the pathogenesis of certain spinal diseases. Collapse or thinning of discs may lead to abnormal mechanical stress on the intervertebral ligaments and periosteum of adjacent vertebrae, which respond by the formation of calcifications and exostoses, resulting, finally, in the development of bony bridges over the narrowed interspaces (Schmorl's "deforming spondylosis", or hypertrophic spondylitis of the Anglo-Saxon literature). Vertebral infections (typhoid fever, Malta fever), injuries, and metastatic malignant infiltrations often produce similar reactive excrescences. Especially noteworthy, however, is the *fact that primary thinning of the disc is a very common cause of spondylosis*; wherefore, in a previous report [12], the term "discogenetic disease" was suggested to designate this form. Furthermore, Oppenheimer and Turner have observed that thinning of the discs in one section of the spine may be associated in another with fragility of the vertebrae and consequent protrusion or herniations of the nucleus pulposus into the softened

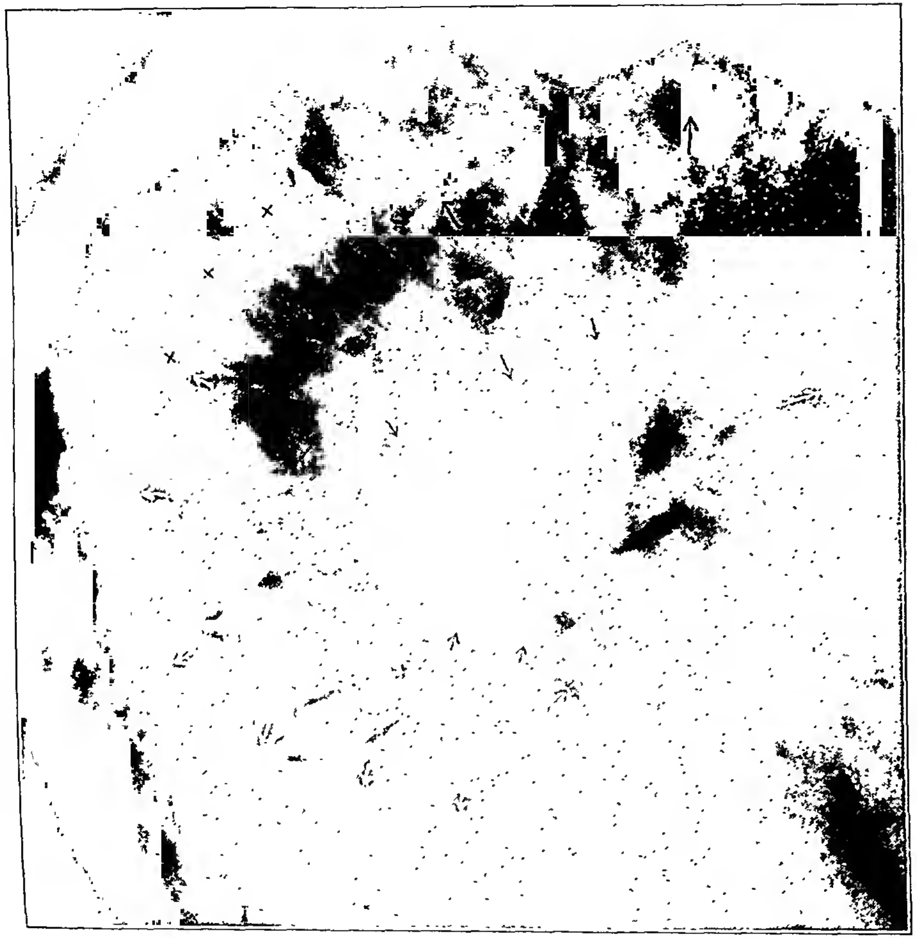

Fig. 4

The thoracic aorta is tortuous, elongated, and partly calcified (arrows). Note the pronounced density of its shadow. Three vertebrae (x) have collapsed.

Fig. 5

Extensive densification with calcareous deposits in the thoracic aorta (arrows). Two vertebral bodies (x) are greatly flattened.

Fig. 6-A Fig. 6-B

Widening of the intervertebral spaces:
Fig. 6-A: In Gaucher's disease (retouched).
Fig. 6-B: In an elderly porter.

bony surfaces of the contiguous vertebrae; accordingly, they conclude that thinning of the discs, unless consequent upon recent or remote trauma, is a degenerative disease which may have its origin in disturbances of nutrition (as produced experimentally by Bernstein). However, the morbid condition discussed in this paper is the converse or complementary picture, as it were, of the discogenetic disease.

It has been shown by Baron and Bársony, Smith, Moffat, Wagoner and Pendergrass, and others that softening of the vertebral bodies allows a normal disc to expand in proportion to the diminution of the bony resistance that the vertebrae normally oppose to the elastic expansibility of the disc. This occurs, for example, when a morbid process in the vertebral body has not yet involved the disc. As the disc receives its nutriment exclusively by diffusion from the vertebral bodies (through their lamina cribrosa), it depends upon the nature, extent, and degree of the morbid process in the bone whether the disc shall be affected simultaneously with the vertebra, or later, or whether the disease shall be arrested before the disc is involved (or without involving the disc). For example, there are certain rarefying conditions in which the process is for many years confined strictly to the bones, which become more and more flattened, while the discs expand correspondingly; this is known to occur in tuberculosis, after fractures, and in Gaucher's disease (Fig. 6-A). We have also observed multiple formation of "vertebra plana" after injury in persons who have soft vertebrae, as shown by generalized widening of the intervertebral spaces in sections of the column not affected by the trauma

(Fig. 7). In three cases of this nature, examined during the last two years, laboratory tests revealed neither abnormalities of calcium metabolism nor any other signs of hyperparathyroidism. Slight widening of the intervertebral spaces may occur also in ankylopoietic spondylarthritis of the Bechterew type (Fig. 8-B) or in the group of diseases associated with calcification of the longitudinal ligaments without involvement of the articulations (spondylosis ossificans ligamentosa) (Fig. 8-A). Finally, one may occasionally find moderate flattening of vertebrae with slight enlargement of the intervertebral spaces and moderate exostotic formations in patients subjected to excessive and prolonged mechanical stress, as, for example, porters in Oriental seaport towns (Fig. 6-B).

From the morbid conditions mentioned, the one under discussion is distinguished by its coexistence with a high degree of calcification of the aorta, especially in its abdominal portion, and by a more or less characteristic localization of the morbid process. Although the disease is systemic, the changes are most marked in the midthoracic section of the spine, at the thoracolumbar junction, and in the upper lumbar vertebrae, in

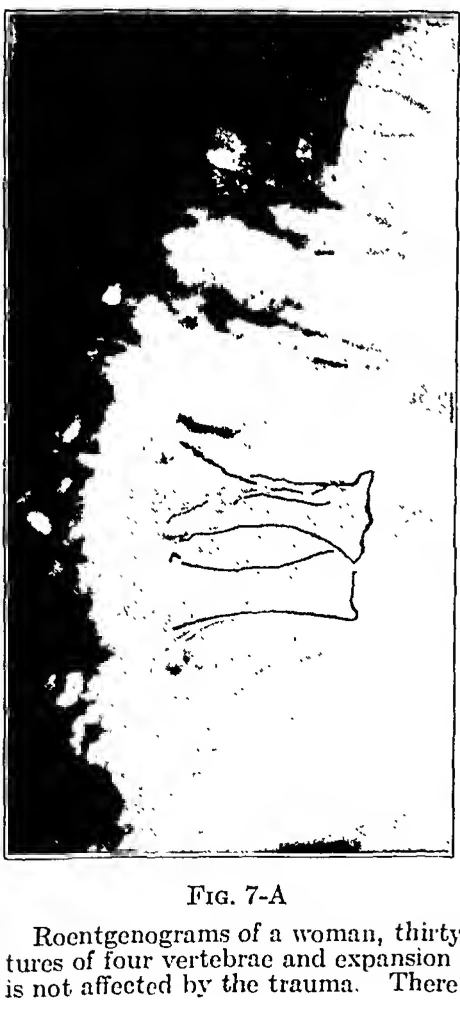

FIG. 7-A

FIG. 7-B

Roentgenograms of a woman, thirty-two years of age, showing compression fractures of four vertebrae and expansion of the discs in the lower lumbar spine which is not affected by the trauma. There is no aortic sclerosis.

FIG. 8-A

FIG. 8-B

Slight widening of the intervertebral spaces:

Fig. 8-A: In spondylosis ossificans ligamentosa. Note the calcification of the anterior longitudinal ligaments (x) in the absence of any changes of the apophyseal articulations (arrows).

Fig. 8-B: In ankylopoietic spondylarthritis. Note ankylosis of the lower apophyseal joint (black arrows) and roughening of the facets in the upper apophyseal joint (white arrows). There is no calcification of the ligaments.

which regions the flattening of the vertebral bodies may amount to actual collapse, whereby the superjacent and subjacent discs seem to come in contact with each other in the center of the vertebral body. Consequently, the intervertebral space appears almost globular, the vertebral body having a deep spoon-shaped excavation of the bone on both its upper and lower surfaces. When this collapse eventually involves all parts of the vertebral body, marginal as well as central, the latter may appear plane, but it is noteworthy that even then the adjacent interspaces may remain wide, showing that the disturbance, even if very well marked, does not necessarily impair the normal elasticity of the disc. In one case only, there was some doubt as to whether two discs were involved in the process and slightly flattened.

One may find various stages of the disease in the selfsame person and at the same time; some vertebrae, although increased in radiolucence, may show only a slight exaggeration of the normal concavity of their upper and lower borders, while other sections of the column show definite expansion of the discs, and in two or three vertebrae the changes may amount to actual collapse. Usually, the cervical spine, although definitely demineralized, shows only very slight deformities, if any; similarly, the upper half of the thoracic region and, commonly, the lower thoracic vertebrae also show very little change. On the other hand, the regions between the fifth and the eighth thoracic vertebrae, and the twelfth thoracic and the first and second lumbar vertebrae, are commonly the sites of the most profound alterations.

This statement holds true even in those very early stages of the disease in which there is not yet any definite decrease in the height of the vertebral bodies. During this period, increased concavity of the vertebral bodies is perceptible only in the middle portion of the thoracic spine and in the upper lumbar spine, while the other segments show demineralization, but no change in shape. The disease seems to progress very slowly; in two instances, reexamination after fifteen and nineteen months, respectively, revealed only very slight accentuation of the process.

Generally speaking, there are very few reactive changes in this disease. As already stated, very slight calcifications may occur in the longitudinal ligaments, or small exostoses at the anterior borders of one or two vertebrae. It is questionable, however, whether these changes are consequent upon the process in question, as they are very common in persons above fifty years of age and may be merely residues of some antecedent process. On the contrary, it is just this absence of reactive ossifications which is in such striking contrast with the high degree of alteration of the vertebral bodies; indeed, their absence is almost pathognomonic, for other rarefying processes of similar chronicity almost invariably induce large "supportive" exostoses springing from the vertebral bodies.

It is noteworthy that ossification of the costal cartilages may coexist with platyspondylia aortosclerotica, although in two cases no such incrustation was present. No opaque calculi have been seen in the abdomen, nor calcifications in other parts of the body.

Clinically, no evidence of parathyroidism was found. In one instance, a slight increase in blood cholesterol was the only biochemical alteration detected by laboratory test. In another case, the blood pressure was moderately increased (160/80), but no other significant changes were found. As previously mentioned, all bones other than the affected vertebrae were normal both clinically and roentgenographically; in particular, there was no evidence of abnormal fragility or pliability. In no case did the history suggest the presence of an avitaminosis, nor were there any symptoms or signs indicative of such a condition. There was no fever; the blood counts were normal; and there were no signs of a chronic or focal infection, nor of any involvement of the spinal cord and roots. In spite of the high degree of calcification of the abdominal aorta, none of the patients complained of abdominal discomfort, but all of them had slight circulatory weakness corresponding to a moderate degree of muscular insufficiency of the heart. No stenocardiac attacks were complained of, nor did we find in any case evidence of congestive heart failure. The peripheral arteries were not calcified, nor were there any signs of definite cerebral arteriosclerosis. Incidentally, in the presence of calcified peripheral arteries, rarefaction of the spine has not been found. All of our patients were still able to do a moderate amount of physical work and to attend to their usual occupations, such as housekeeping and office work; none of them had been subjected to any abnormal physical strain.

DISCUSSION

Systemic rarefying processes of the vertebral column are already known to occur as part of a generalized involvement of the entire skeleton, as, for example, in hyperparathyroidism, in Gaucher's disease and allied affections, and in some other cases of unknown origin. In all these conditions, widening of the intervertebral spaces, indicating expansion of the discs, is also reported. Incidentally, it should be noted that this expansion is totally different in its nature from that which underlies herniation of the nucleus pulposus into the bodies of adjacent vertebrae, for herniation occurs in the form of circumscribed protuberances which pass through the ruptured lamina cribrosa of an otherwise unchanged vertebra; whereas, in the condition mentioned, the entire disc expands because the whole of the adjacent bone has grown soft.

Over and above the changes in the spinal column, the observations on which this report is based reveal the presence of a striking and hitherto undescribed factor,—namely, a very unusual amount of calcareous deposit in the aorta, both in the thoracic and in the abdominal portions. Neither clinical nor roentgenographic examinations nor laboratory tests have thrown any light on the nature of this coexistence of aortic calcification with spinal decalcification. Are these objectively distinct phenomena really interrelated, or does the aortic disease play a causative part in the development of the spinal lesion, as, for example, by interference with the blood supply of the vertebral bodies? Nevertheless, it is to be noted that there is some correspondence in degree between the aortic lesion and the spinal lesion, at least to the extent that the most pronounced spinal lesion observed coexisted with the most marked aortic calcification, and *vice versa*. On the other hand, we have seen very marked and extensive calcification of the abdominal aorta in three patients who did not show any changes of the vertebral column, which agrees with Norlén's statement that there is no definite interrelation between arteriosclerosis and degeneration of the discs. This observation, together with the fact that some segments of the spine may escape entirely, while others show marked compression of the vertebral bodies, would seem to indicate that aortic sclerosis of this kind does not of necessity produce such changes in the spine as those described. Moreover, if there were such a causal connection between the aortic and the spinal lesions, some interference with nutrition should be visible in other parts of the skeleton, as well as in the vertebrae. The complete absence of signs of any kind indicative of metabolic disorder, especially parathyroidism, agrees with the fact that the bone lesion is strictly confined to the vertebral bodies. On the other hand, the regular coexistence of such a severe vertebral lesion with a degree of aortic calcification never before observed roentgenographically, and the constancy of the roentgenographic findings as regards localization and the aspect of individual vertebrae weigh heavily against the assumption that such correspondence is merely accidental. As long as the pathogenesis of arteriosclerosis remains obscure, the diseases associated

with it can hardly be elucidated; accordingly, we are unable to offer any consistent theoretical explanation of the process, or processes, underlying this form of platyspondylia; but the existence of other diseases or morbid conditions similarly confined to one section of the body lends some support to the old and popular belief that certain forms of disease may be localized in special regions of the body,—left or right, anterior or posterior, as the case may be. The regional distribution of many skin diseases, the contrast between central and peripheral arteriosclerosis, and the course of certain progressive nerve lesions are some examples out of many to illustrate this old conception. On reviewing observations of this nature, one is tempted to agree with our pathologist, Dr. E. Mayer, who, when first shown the material on which this report is based, closed the discussion dryly with the remark: "It seems as though these persons were diseased posteriorly!"

The disease here discussed is the converse or complement in every respect of the process to which, in a previous report[12], we gave the name of "discogenetic disease"; this is true not only as regards the obvious difference in behavior of the intervertebral discs, but also as regards the reactive response of the supporting tissues. Finally, those regions that are most commonly involved in discogenetic disease—namely, the cervical and lower lumbar—remain almost free in the process here discussed; whereas the thoracic region, which shows the most pronounced collapse in platyspondylia aortosclerotica, is invariably free in discogenetic disease. Clinically, the difference is marked as regards the complaints made by the patients themselves. Owing to the frequent involvement of the intervertebral foramina in discogenetic disease, pain and disability, due to segmental neuritis, are the chief causes of complaint; in fact, the patient's *complaint* in discogenetic disease is more marked than the objective findings. However, in platyspondylia aortosclerotica, expansion of the discs prevents narrowing of the intervertebral foramina; accordingly, neuritis was not observed under these conditions.

We suggest the name "platyspondylia aortosclerotica" (flattened vertebrae in aortic sclerosis) as a tentative abbreviation—a sort of stenographic label—which, of course, is merely descriptive.

SUMMARY

1. In six cases, the coexistence of strongly marked calcification of the thoracic and abdominal portions of the aorta with a systemic spinal disease has been observed.

2. In all these cases, the roentgenographic appearance of the spine was identical: demineralization of all the vertebral bodies, collapse of the midthoracic and upper lumbar bodies, and pronounced expansion of the intervertebral discs into the softened vertebrae.

3. Other parts of the skeleton were not involved.

4. Peripheral and cerebral arterioscleroses were not evident.

5. The apophyseal articulations were free, and the intervertebral

foramina were not affected; the longitudinal ligaments sometimes showed small calcifications.

6. Signs of metabolic disturbance or endocrine disorder were not found.

7. Except for the gradual formation of a gibbosity, the disease does not cause marked subjective symptoms.

8. The term "platyspondylia aortosclerotica" is suggested to designate this morbid entity.

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USE OF FASCIA LATA IN KNEE-JOINT INSTABILITY *

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The author wishes to report his experience with the use of fascia lata in the treatment of knee-joint instability as follows:

1. Repair of the anterior cruciate ligament.
2. Support for hyperextension weakness.
3. Repair of the medial ligament.

REPAIR OF THE ANTERIOR CRUCIATE LIGAMENT

A fascial strip, reflected from the outer side of the thigh, is passed around the lateral condyle to enter the posterior compartment of the knee directly over the origin of the normal anterior cruciate ligament. The attachment of the fascial strip is made through a drill hole in the tibia at the point of insertion for the anterior cruciate ligament.

Technique

The entire lower extremity is prepared and, before application of the tourniquet, the strip of fascia is reflected. The incision extends from the lateral condyle along the outer side of the thigh for a distance sufficient to reflect a strip of fascia, eight inches in length and two inches in width, downward to the condyle. The base of the strip remains attached at the lower end. The incision is temporarily closed with forceps, and a sterile tourniquet is applied. Through a medial patellar incision, the joint is inspected, and any additional surgical procedure, such as removal of the meniscus, is carried out at this stage. The lateral incision is again ex-

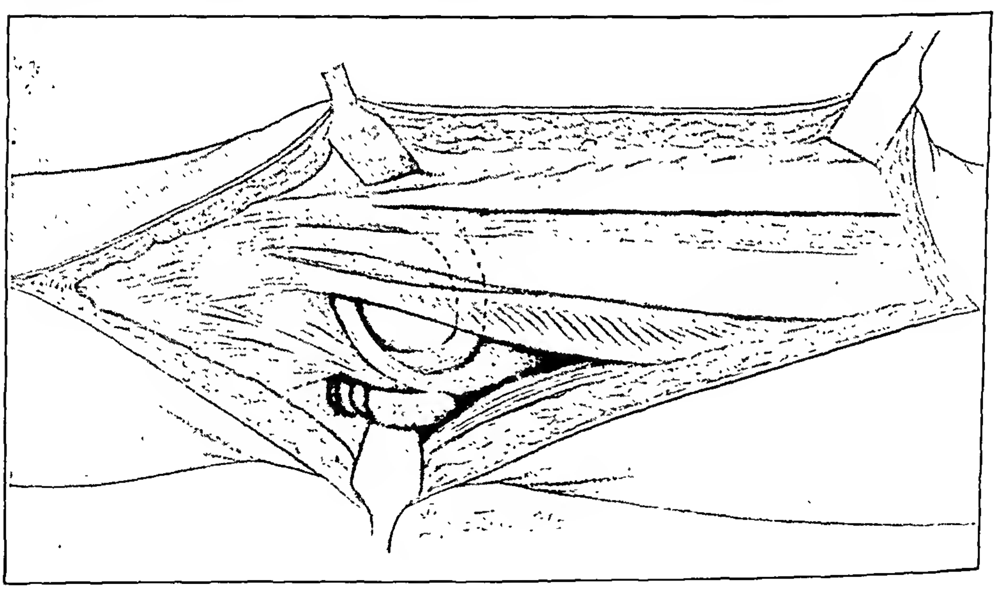

FIG. 1-A

* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons, St. Louis, Missouri, January 15, 1936.

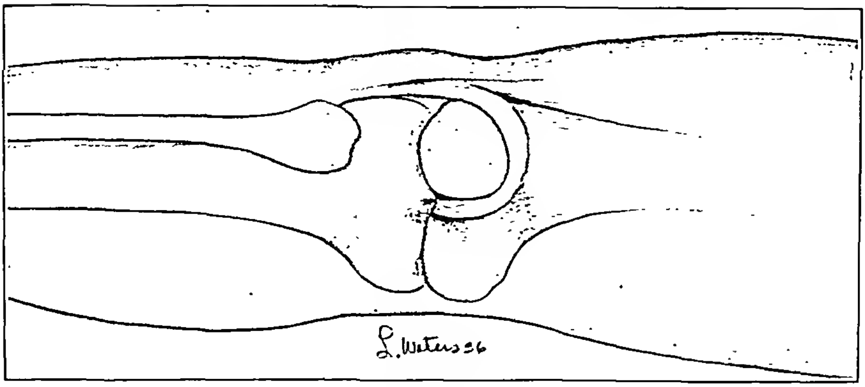

Fig. 1-B

Repair of the anterior cruciate ligament. The lateral thigh and knee are exposed, showing the fascial strip passing into the posterior compartment, directly over the origin of the normal anterior cruciate ligament.

posed, and, in the condylar area, a deeper incision is made through the vastus lateralis to reach the posterolateral surface of the femur just above the condyle. This incision is deepened, and, with a long, narrow retractor, the posterior capsule of the joint is exposed. With this in view, the operator passes a carrier directly through the anterior incision into the joint, which is made to penetrate the posterior capsule and to emerge in the lateral incision. This carrier is similar to an aneurysm needle; it has the proper curve for swinging around the condyle and a large eye to receive the fascia. The strip of fascia is threaded through the eye of the carrier and is then pulled through the knee joint. When properly placed, it passes from its base immediately deep to the femur and thence around the femur against the expanding portion of the condyle to pass over the normal attachment of the anterior cruciate ligament. A drill hole is made through the tuberosity of the tibia, starting on the medial side and emerging in the joint at the center just anterior to the tibial spine. The drilled fragments are carefully removed from the joint. The ligament is pulled through and, under firm tension with the knee at

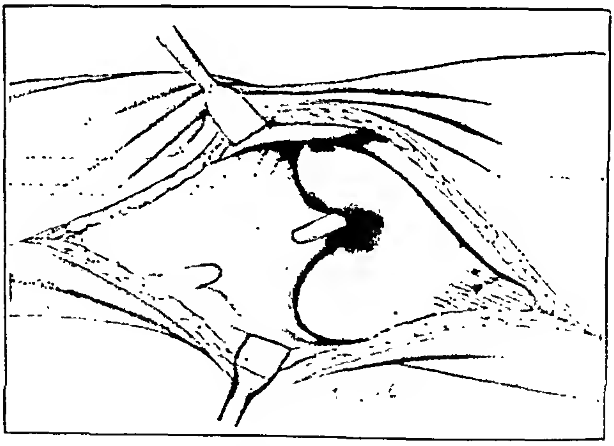

Fig. 2

Repair of the anterior cruciate ligament. The fascial strip is attached to the tibia. A longer end can be used for medial-ligament support.

170 degrees, is fastened securely with silk ligatures at the anteromedial side of the tibia. When indicated, the end is continued upward on the medial side of the knee to lend additional support to the medial ligament. The incision is closed in layers. (See Figures 1-A, 1-B, and 2.)

The knee is put up in plaster in a position of 170 degrees for four weeks. A brace is then fitted and exercises are started, with gradual extension of the leg. The brace should be worn for from sixty to ninety days. The new ligament, passing from the origin to the insertion of a normal cruciate ligament, is mechanically placed for maximum function.

This operation has been performed in the following seven cases with good results.

Case 1. W. C. H., male, aged thirty-eight years.

Six months previous to examination, the patient had been struck on the outer side of the right leg by a truck bumper. He had grasped the front of the car and the leg had been badly twisted, due to dragging of the foot on the ground. There was no fracture, and plaster was worn for two weeks. At the end of this time, the knee was still swollen. The patient remained in bed six weeks, exercising the knee, but bearing no weight. On getting up, the knee was weak and there was a slipping sensation, but no locking.

Examination, on September 29, 1933, revealed a full range of motion, atrophy of the quadriceps, and anterior and medial displacement of the tibia on the femur as the knee was extended during weight-bearing. The patient was on crutches at this time.

A knee brace was applied, and limited use of the knee and quadriceps exercises were advised. At the end of sixty days there was no improvement.

On December 19, 1933, the knee joint was exposed, revealing normal cartilage and complete rupture of the anterior cruciate ligament. A new cruciate ligament was constructed from fascia lata by the technique described. The medial ligament was reenforced by turning the end of the fascia upward to the medial condyle.

The patient returned to his regular occupation as a traveling salesman; he drives through the country and walks freely, with no appreciable limp. He says that the injured knee is not quite as good as the other one. He has never regained full quadriceps power and has a 30-degree limitation of flexion. The result would not be good for athletic work, but is satisfactory as far as his occupation is concerned.

Case 2. M. A. Y., female, aged eighteen years.

Ten months before admission, the patient had slipped on a marble floor and had injured the right knee. A few weeks later, the medial cartilage was removed. Four weeks later, while walking with a cane, the patient tripped and the knee was badly wrenched. The swelling returned and she was unable to use the leg for several weeks. When walking was resumed, the knee gave way, causing several falls. No locking occurred, but there was general relaxation in the joint and the patient could not discard the crutch.

Examination, on October 9, 1931, showed a relaxed knee and abnormal mobility in every direction. The tibia moved forward one inch beyond normal limits. A diagnosis of ruptured anterior cruciate and medial ligaments, following injury soon after the cartilage operation, was made.

On November 6, 1931, the joint was opened; the medial cartilage was absent, both cruciate ligaments were torn, and the ends were retracted. New medial and lateral ligaments were constructed from free strips of fascia attached to the bone above and below. In addition, fascial sutures were interwoven in the expansion of the vastus lateralis, crossing the anterior medial part of the joint. The knee was fixed in plaster for three months, followed by a brace and quadriceps exercises.

There was improvement in lateral stability and general function, but the patient could not discard the brace. Anterior posterior instability persisted. Consequently,

on April 21, 1932, an operation was performed to restore the cruciate ligaments. The posterior cruciate ligament was reformed from the biceps, according to the technique of Cubbins; the anterior cruciate, from the tensor fasciae femoris reflected in the manner described.

The knee is stable with motion from 180 to 100 degrees. The patient walks without any appreciable limp and can walk any distance without fatigue. He has difficulty with stairs, due to limited flexion.

CASE 3. M. J., female, aged twenty years.

The patient gave a history of a Neisserian infection one year previous to admission. At examination, on February 5, 1929, the left knee was found to have 20 degrees of motion (from 90 to 110 degrees) and was slightly painful. The patient used a crutch.

A posterior capsulotomy was done, which resulted in fibrous ankylosis between the femur and the tibia in a position of 165 degrees.

On October 16, 1932, an arthroplasty was performed, and a heavy mass of scar and osseous tissue was freely dissected from the posterior structure. This resulted in good motion, fair lateral stability, and poor anterior posterior stability. During weight-bearing, with the knee in a position of 200 degrees, the tibia slipped forward on the femur.

On April 19, 1934, a new anterior cruciate ligament was made, according to the technique described. Subsequent examination showed the new articulating surfaces covered with smooth fibrous tissue and the presence of clear fluid. The knee is stable with good function and motion from 185 to 120 degrees. The patient has a moderate limp and walks any distance without fatigue.

Instability in this case was due to damage of the medial and lateral soft tissues in the treatment of the flexion deformity prior to arthroplasty.

CASE 4. R. E. V., male, aged twenty-eight years.

The patient had been caught in a line shaft and had sustained multiple injuries, including several fractures. Instability of the right knee had persisted over a year.

Examination, on February 27, 1933, revealed anterior and medial rotation of the tibia on the femur, relaxation, and instability. An old fracture of the medial plateau of the tibia had united in fair position.

The joint was exposed and the cartilage was found to be intact. The anterior cruciate ligament was torn and retracted, and the medial side of the joint was relaxed. A strip of fascia lata was reflected to the condyle, thence behind and through the joint into the tibia and upward to support the relaxed medial ligament.

As a result, the patient had a full range of motion, with no appreciable limp, and returned to his former occupation.

CASE 5. L. W., male, aged twenty years.

In October 1934, during a football scrimmage, the patient had twisted the right knee severely, and in a few hours swelling and pain had occurred. There was no locking, and full extension was possible. He used crutches for three days and a cane for three weeks. He was unable to return to playing football. The knee was weak and loose, with a slipping sensation frequently during walking.

Examination, on May 25, 1935, revealed relaxation of the joint, full extension, and anterior and medial displacement of the tibia on the femur. A diagnosis of rupture of the anterior cruciate ligament was made.

At operation, the joint was exposed and the internal cartilage was removed: the anterior cruciate ligament was found to be completely ruptured. A new ligament was formed from fascia lata through the joint into the tibia; the medial ligament was not reenforced.

Good function was obtained in four months; slight medial relaxation persisted. The patient was allowed to run, but was not permitted to play football for eight months.

In this case, the fascial strip should have been cut long enough to reflect from the tibia on the medial side for reenforcing the medial ligament.

CASE 6. D. A., male, aged eighteen years.

The patient had sustained a football injury four months previous to admission. He had been unable to straighten the right knee, and there was a feeling of weakness and aching after walking. Following the injury, he had kept off the leg for four or five days. He had been walking poorly since that time.

On January 20, 1933, a diagnosis of internal-cartilage injury, with partial rupture of the anterior cruciate ligament, was made.

At operation, the joint was exposed, revealing a bucket-loop injury to the medial cartilage and complete rupture of the anterior cruciate ligament. The cartilage was removed and a new anterior cruciate ligament was made from fascia lata in the manner described. The medial ligament was not reenforced.

An excellent result was obtained, and the patient was able to engage in football and other athletic sports after eight months.

CASE 7. M. S., male, aged seventeen years.

Sixty days previous to admission, the patient had been in a car wreck, and the left knee had been badly wrenched. Swelling and disability occurred immediately. The patient was given rest in bed, with no fixation of the joint. Two weeks later he was permitted to be up on crutches, and an effort to use the knee was made. At the end of two months on crutches, the knee was relaxed and would not sustain weight. The tibia moved forward and backward and to the medial side. A diagnosis of rupture of the cruciate ligaments and of the medial ligament was made.

On August 28, 1931, exposure of the joint revealed rupture of the anterior and posterior cruciate ligaments. The torn medial cartilage was removed and the medial side of the joint was stabilized with free fascial transplants, fastened in the bone at the femur and the tibia. The knee was fixed for three months.

This operation resulted in persistent instability. The tibia moved forward and backward on the femur, and the knee function was poor. Consequently, on June 30, 1932, the cruciate ligaments were reconstructed. The posterior ligament was formed from the biceps tendon, according to the method of Cubbins. The anterior ligament was formed by reflecting a strip of fascia lata behind the condyle through the joint into the tibia, as previously described.

The result was fair; some abnormal mobility was present, and there was a 25-per-cent. disability of the knee.

This group, though small, represents severe and unusual types of injury. In most instances, the early treatment had been inadequate. Rechecking, after from one to four years following operation, gives conclusive evidence of permanency of the acquired stability.

Patients with uncomplicated cruciate-ligament injury, and even those with associated rupture of the collateral ligament, will recover with good function in most instances, if early and adequate fixation is established.

SUPPORT FOR HYPEREXTENSION WEAKNESS

A strip of fascia reflected from the outer side of the thigh, two inches wide and eight inches long, is passed between the tibia and the fibula, just below the head of the fibula, to reach the posterior compartment behind the knee joint. The strip is drawn upward in contact with the posterior capsule, passed through two drill holes in the posterior surface of the femur, and then directed downward to emerge on the anterior surface of the leg through the same compartment between the tibia and the fibula. It is attached under tension with silk ligatures.

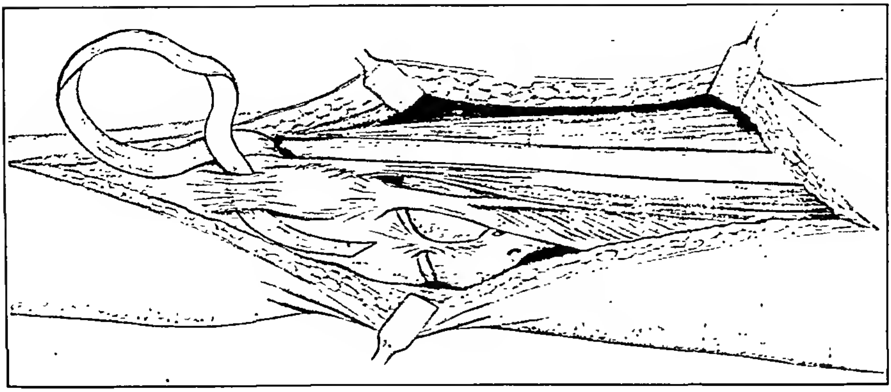

FIG. 3
Fascial strip for hyperextension. The posterior lateral exposure is used for illustration only. The popliteal muscles prevent full view in the actual operation.

Technique

A long incision is made on the lateral surface of the thigh, extending downward below the head of the fibula. A strip of the iliotibial band, two inches wide and measuring approximately eight inches above the condyle, is divided above and reflected down the thigh. On reaching its attachment on the tuberosity of the tibia, a small portion of periosteum is reflected with the fascia and for an additional inch the continuation is the fascial expansion of the leg. In crossing the joint, care is exercised to separate fascia from capsule, so that the latter may not be opened. The incision above the knee is then carried deeper, exposing the posterior surface of the femur, the condylar areas, and, in the deep inferior portion, the capsule of the knee joint. This part of the incision is the same as for capsuloplasty. Two drill holes are made in the femur at the junction of the shaft and the expanding condyle,—one at the posterolateral juncture, another well to the medial size. A medullary connection is made between the two drill holes. A drill, three-eighths of an inch in diameter, is the proper size. With the knee in flexion, a curved guide is introduced between the tibia and the fibula and made to emerge into the posterior space behind the femur. It will be necessary to incise over the end of the guide the redundant folds of capsule. Another guide, introduced from above and posteriorly, is carried through this opening to emerge between the tibia and the fibula on the anterior surface. The fascial strip is attached and

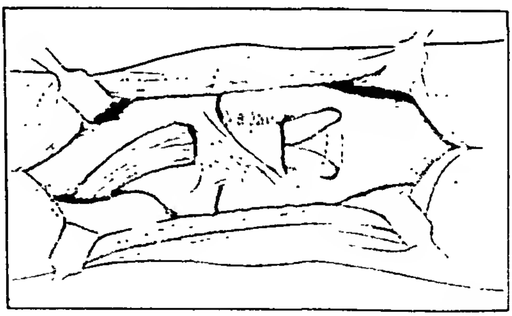

FIG. 4
Fascial strip for hyperextension. Visualization of the proper relation of the fascial strip to the posterior portion of the knee joint.

Fig. 5-A Fig. 5-B
Hyperextension deformity.

pulled through to the posterior femoral area. It is then carried through the drill holes, entering the one on the medial side and emerging through the one on the lateral side. A wire loop is used for guiding the strip through this area. The guide is then reintroduced from below upward to bring the fascial strip back, making a double structure on the posterior surface of the knee. The fascial end is secured with silk ligatures under the desired tension. The knee should be in flexion of 10 degrees more than is desired for future function. This is important, because it has been found that, with firm tension applied in a fixed position, an additional 10 degrees of stretching will occur in the progress of recovery. The leg is put up in plaster, and the position is secured for eight weeks. On removal of the plaster, a brace is fitted, and gradual extension is secured. (See Figures 3 and 4.)

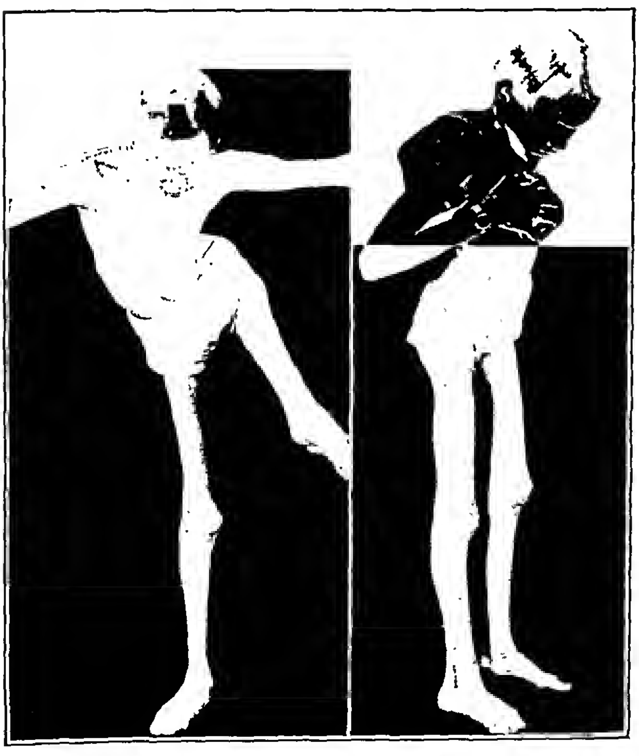

Fig. 6-A Fig. 6-B
Same patient, two years following operation.

This operation, apparently sound, has been done in twelve cases. The case with the longest postoperative period (two years) has recently been checked and the indications are that the support is adequate. (See Figures 5-A, 5-B, 6-A, and 6-B.) In no instance has there been a recurrence of hyperextension.

The deformities in these cases resulted from poliomyelitis, and other disabilities were associated. The children ranged in age between eight and fifteen years. In two cases it was necessary to wedge the knee into hyperextension of 10 degrees six months

after operation, because postoperatively the knee was placed in 10 degrees of flexion and remained tight at 180 degrees. Wedging was carried out slowly, and sufficient time has not elapsed to determine if the new position will hold.

Final reports on this series will be made in a few years. However, the author has confidence in the procedure and will continue to employ it when indicated.

REPAIR OF THE MEDIAL LIGAMENT

Most ligament injuries, even of severe grade, can be repaired satisfactorily with good fixation and conservative treatment. Extensive laceration and poor management may result in an extremely unstable joint. In this type of case it is desirable to preserve the medial fascia with its connection to the aponeurosis of the vastus medialis for the additional support on the inner side of the knee. In 1928 and 1932, in two cases the ligaments were repaired by reflecting a strip of the iliotibial band down the outer side of the thigh and passing it through a drill hole in the condyles, barely missing the supracondylar notch. The fascia, emerging just below the medial epicondyle, was reflected downward across the joint and fastened securely into the tibia and the fascia of the leg. The results were satisfactory. The final modification of the procedure, which we have done in a few cases, is simpler and as effective.

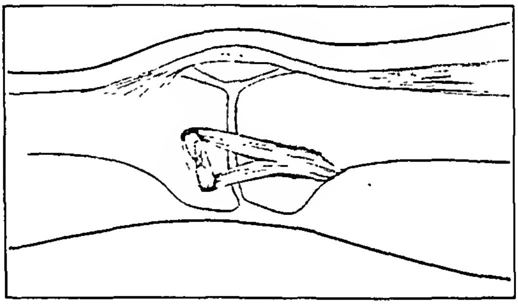

FIG. 7

Repair of the medial ligament of the knee. A strip of fascia lata emerges from the posterior surface of the femur to pass over the epicondyle for attachment on the tibia.

Technique

A strip of fascia from the iliotibial band is reflected downward to a point just above the lateral condyle. The strip should be two by eight inches. The medial side of the knee is then exposed, and, through a stab wound in the deeper tissues, a guide is passed directly behind the femur just above the condyles to emerge on the lateral side through the vastus lateralis and to secure the fascial strip. The fascia is pulled through and on the medial side is reflected forward to the center of the condyle; it is then pulled directly downward to the medial side of the tibia. On the surface of the femoral condyle, where the fascia is in contact, a channel is made by introducing a broad osteotome and lifting backward a layer of bone and fascia, permitting the fascia to come in direct contact with the freshened bone. Two drill holes are placed an inch apart on the medial

side of the tibial tuberosity. The fascia is split and each half passes through one hole and emerges at the other. The ends are secured under tension with silk ligatures. (See Figure 7.) The incisions are closed and the leg is put up in a straight position with plaster from the toes to the groin. A walking boot is attached, and the plaster is worn for eight weeks. Gradual resumption of flexion and function, with quadriceps exercises, is followed for another forty to sixty days.

One of the cases is reported because of its unusual character.

C. M., female, aged thirty years.

Eighteen months previous to admission, the patient had had an abortion with infection, complicated by suppurative arthritis of the knee. Bilateral drainage had been maintained for three months.

Examination, on June 19, 1929, showed sound ankylosis, flexion of 130 degrees, genu valgum of 20 degrees, healed three-inch scars on both sides of the knee, poor quadriceps function, and fusion of all bones.

An arthroplasty, performed on November 30, 1929, resulted in poor stability but good motion. The medial and lateral soft structures had been damaged by previous drainage, with resultant scar tissue.

On October 18, 1932, examination showed marked instability; on weight-bearing the tibia rotated forward and inward, and the patella subluxated outward. Consequently, an operation to repair the medial ligament was done. The patellar tendon was transferred to the anterior medial surface of the tibia, a bone graft (ledge of bone) was placed in the upper end of the tibia on the medial side, and a strip of fascia was reflected down the femur and passed through a drill hole, to emerge on the medial side for attachment to the tibia after crossing the joint.

As a result of this operation, the joint is stable and there is no displacement of the tibia to the medial side on weight-bearing. There is motion from 180 to 100 degrees. The patient walks without a cane with an easy gait, and she has only a slight limp.

A bone block was added in this case, because of extreme displacement. The fascial strip would probably have been adequate.

RECURRENT OR HABITUAL DISLOCATION OF THE PATELLA

A Critical Analysis of Twenty Cases *

BY M. THOMAS HORWITZ, M.D., PHILADELPHIA, PENNSYLVANIA

From the Orthopaedic Services of the Hospital for Joint Diseases, New York City

The twenty cases of recurrent or habitual dislocation of the patella on which this paper is based were taken from the private and service files of the Orthopaedic Services of the Hospital for Joint Diseases, New York City. There were twelve females and eight males, varying in age from seven to forty-three years: one patient was seven years old; eight were between the ages of twelve and twenty; four were between twenty-one and thirty; five were between thirty-one and thirty-nine; and two were between forty and forty-five. Two cases were bilateral and eighteen were unilateral; of the latter, the right knee was involved in nine cases and the left knee in nine.

DURATION OF ILLNESS

This period varied from one month to twenty-three years, as follows:

Period	*No. of Cases*
1 month	1
3 to 6 months	4
1 to 5 years	8
6 to 10 years	3
11 to 23 years	4
	20

RELATION OF TRAUMA

A definite history of injury was obtained in fifteen cases. In three of the remaining five cases, the history of trauma was indirect. In one of these the roentgenograms revealed Pellegrini-Stieda disease; another evidenced a marked synovitis of the affected knee; while the third was a case of Legg-Calvé-Perthes disease of the opposite hip, in which a brace had been worn for three years and abnormal stresses had been required on the opposite side,—*i.e.*, the side of the affected knee.

Of this group of eighteen cases in which trauma was directly or indirectly a factor, seventeen were unilateral and one was bilateral. In the remaining two cases, there were definite evidences of congenital anomalies, with deficiency of the lateral femoral condyle, genu valgum, and an underdeveloped, laterally displaced, and upward-riding patella.

Of the fifteen patients with a definite history of trauma, eight had had an acute, painful dislocation initially, requiring reduction and immobilization. In none of these cases had there been preceding symptoms, but weakness and disability had existed thereafter. Only two of these patients presented underlying congenital or anatomical defects.

* Received for publication April 28, 1937.

In the remaining seven patients, the injury was milder and without acute disability. All of these patients had had previous symptoms of weakness and instability. Six of them had some underlying defect such as genu valgum, a deficient lateral femoral condyle or intercondylar sulcus, and an underdeveloped and laterally displaced patella, usually present bilaterally.

In the traumatic group of fifteen cases, there were four cases of a torn medial meniscus: in two cases, the medial meniscus was removed at the time of reconstruction of the dislocated patella; in one, one year prior to the plastic procedure, without relief of symptoms; and in the fourth, three months after the repair, because of persistent complaints. An abnormally loose medial meniscus was also removed in one case at the time of reposition of the patella.

There was one instance of concomitant osteochondritis dissecans and one of synovial osteochondromatosis.

The injury in these cases usually consisted of a fall with indirect trauma to the knee. Direct injury occurred in but one case. In three cases, the trauma was a mere twist of the knee, during an attempt to lift a load.

SYMPTOMS

The following symptoms were observed:

Symptoms	*No. of Cases*
Weakness of the affected knee	20
Sensation of the knee's giving way	17
Lateral slipping of the patella, especially with the knee flexed	17
Pain, swelling, tenderness, and a limp	7
Definite history of "locking" of the knee. (The number of recurrent attacks, in all of which reduction was possible, varied from one to six.)	6

PHYSICAL FINDINGS

Physical examination revealed the following abnormalities:

Abnormality		*No. of Cases*
Outward displacement of the patella, exaggerated by knee flexion		20
Genu valgum		7
Unilateral, each with definite history of trauma	5	
Bilateral, one with history of trauma	2	
Underdeveloped patella		7
Diminution in range of motion		5
Diminished prominence of the lateral femoral condyle		3
Lateral instability of the knee		2
Palpable foreign body		1

ROENTGENOGRAPHIC FINDINGS

Roentgenographic examination disclosed the following abnormalities:

Abnormality		No. of Cases
Outward displacement of the patella		20
Underdeveloped patella		11
Fracture of the patella		4
Underdeveloped lateral femoral condyle		3
Osteo-arthritis of the lateral femoral condyle and of the posterior surface of the patella		2
Patella bipartita		2
Bilateral	1	
Unilateral	1	
Patella tripartita (bilateral)		1
Fracture of the medial tibial condyle		1
Osteochondritis dissecans		1
Synovial osteochondromatosis		1
Pellegrini-Stieda disease		1

PATHOLOGICAL FINDINGS

A deficient intercondylar sulcus was noted in seven cases. Osteo-arthritis of the lateral femoral condyle and of the posterior patellar surface, with erosion and fibrillation of the cartilage, was present in four cases.

There was a frank tear of the medial meniscus in one case, a diseased and fibrillated medial meniscus in another, and an abnormally loose medial meniscus in a third. It is opportune to note once again that a torn medial meniscus had been removed in one case one year prior to, and in another three months following, the repair of the patellar displacement.

Fracture of the patella was noted in four cases; in three of these, the medial patellar retinaculum was also torn.

Free bone fragments were present in one case of synovial osteochondromatosis, in one case of osteochondritis dissecans, and in one case of fracture of the medial tibial condyle.

An abnormal transverse band was present, bilaterally, between the lateral femoral condyle and the patella in one case, which maintained the lateral dislocation until it was sectioned.

An organized blood clot was found in the knee joint in one case; while in another there was a hemangioma of the soft tissues anterior to the knee joint, bearing no relation to the patellar displacement.

A congested postpatellar fat pad was partially resected in one case.

TREATMENT

The treatment was operative in every case.

The Goldthwait procedure was utilized in five cases, in two of these with the additional reefing of the internal capsule. By this operation the patellar tendon and the tibial tubercle are exposed through a five-inch incision. The former is then split into a medial and a lateral half and the outer portion is freed from its attachment to the tubercle, drawn inward beneath the intact inner half, and sutured to the periosteum, together with the expansion of the sartorius tendon, on the inner side of the anterior surface of the tibia. The only variation from this technique consisted in

the removal of a small segment of the tibial tubercle along with the lateral half of the patellar tendon, to be mortised into a trough made at the new site of insertion, so that a firm osseous attachment might be secured.

The Albee operation was performed in six cases. In this procedure, through a semilunar incision over the outer border of the patella, extending from the tibial tubercle to a point above the lateral femoral condyle, the condyle is exposed, osteotomized on its lateral surface, one-half to three-quarters of an inch behind the anterior surface, and elevated to a plane above that of the medial femoral condyle by producing a greenstick fracture near the intercondylar groove. The position of this fragment is maintained by a wedge-shaped segment of bone removed from the tibial crest and fixed *in situ* with dowel pins. In two of these cases, this procedure was combined with medial and downward transplantation of the tibial tubercle and its attached patellar tendon.

In our cases, fracture at the lateral femoral condyle was often not a greenstick fracture, but a complete fracture, yet this did not vitiate the good end results. Roentgenograms, taken several years postoperatively in some of these cases, failed to reveal any incongruity of the articular surfaces.

Medial and downward displacement of the tibial tubercle was performed, along with reefing of the relaxed internal capsule, in three cases.

In a severe bilateral case (N. D.), probably of congenital origin, an original modification was devised and employed by Dr. Leo Mayer. A twelve-inch incision, in the shape of a hockey stick, was made with the long arm on the external aspect of the thigh and the lower portion of the incision corresponding to the patellar tendon. The capsule lateral to the patella was incised vertically for a distance of four inches, and then the synovia of the joint itself was incised, allowing reduction of the displaced patella. The patellar tendon was cut away from its attachment, together with a small segment of the tibial tubercle, thus allowing free inspection of the interior of the joint, and was transplanted medially and downward, mortised snugly into its new bed, and surrounded with numerous bone chips. On the right side, a torn medial meniscus was removed; while on the left, an abnormally loose medial meniscus was extirpated through a separate three-inch incision at the inner portion of the joint. The next step consisted of reefing of all the structures on the internal aspect of the joint by overlapping first the synovial layer and then the capsule by a series of three overlapping fascial sutures, the first two by interrupted mattress sutures and the last by a continuous stitch. The final step was the covering of the resultant gap in the external portion of the joint by a flap of fascia lata, two inches wide and six inches long, dissected from the outer aspect of the thigh, turned on itself, and fastened in place with No. 1 chromic catgut. This procedure was performed on each side, with an interval of one month between operations, and was repeated more effectively on the right side in four months.

In one case, medial and downward transplantation of the tibial

tubercle was combined by Dr. Mayer with the recently described Ober fasciaplasty. The Ober procedure consists of: the liberation of a strip of fascia lata, six inches long and one-half an inch wide, from the outer aspect of the thigh, the lower end being left attached; the division of abnormal bands of tissue stretching between the lateral surface of the patella and the lateral deep structures and intermuscular septum; and the passage of this fascial strip beneath the patellar aponeurosis and through a tunnel on the medial aspect of the tibia in the region of the hamstring insertion, the latter being made through a separate three-inch incision. This strip effectively maintains the reduction. In this case (E. L.), a fascial strip, two and one-half inches wide and four inches long, following the medial and downward displacement of the tibial tubercle, was removed from the outer aspect of the thigh, its inferior attachment being preserved, and was brought over the lower end of the patella and sutured to the new site of insertion of the tibial tubercle, thus reenforcing it.

It is questionable to whom priority relative to the introduction of the complete transplantation of the tibial tubercle is due. This procedure has been utilized by Albee and others, but Tubby, in 1912, noted its use "by numerous surgeons" in his book entitled "Deformities".

In one case, the dislocation of the patella was reduced and the relaxed internal capsule simply reefed, maintaining the patella after reduction in its normal position.

In three cases, the dislocation of the patella was reduced and the accompanying torn medial patellar retinaculum was repaired,—in one case by simple interrupted and continuous chromic sutures; in the other two, by a reconstruction of the medial patellofemoral ligament with fascia lata. The latter procedure was performed in both cases by Dr. Henry Milch. Briefly, through a medial four-inch incision, the degenerated fibers at the insertion of the vastus medialis, the hiatus in the patellar retinaculum on the medial side of the knee joint, and the frayed transverse fibers of the patellofemoral ligament were noted. In both cases healing longitudinal fractures of the patellae were also observed. In one case (E. T.), a congested postpatellar fat pad was partially resected. A strip of fascia lata, a quarter of an inch wide and ten inches long, was removed with a fascial stripper from the outer aspect of the thigh, and this was run through a coronal drill hole in the patella, including both fracture fragments, thence through a hole in the medial femoral condyle in the region of the adductor tubercle. The patella was forced medially, so that when the fascial graft was sutured securely to itself, the patella held firmly to the medial side. The leaves of the torn patellar retinaculum and the patellar periosteal flap, previously elevated, were then imbricated one above the other.

This method closely simulates the operation described by Gallie and Le Mesurier, who also used a strip of fascia lata, run through two transverse drill holes in the patella and corresponding drill holes at the inner condyle of the femur, and sutured tautly to itself with the patella displaced medially. Soutter pointed out that, whereas the relationship of the

TABLE I

ANALYSIS OF TWENTY CASES OF RECURRENT OR HABITUAL DISLOCATION OF THE PATELLA

Patient	Age (*Years*)	Duration of Symptoms	Side Affected	Operative Procedure	Additional Surgery	Duration of Follow-Up	End Results
J. Z.	12	4 years	Left	Goldthwait		14 months	Excellent *
E. S.	19	6 years	Right	Goldthwait		4 months	Out of plaster 1 month. Position of patella, normal. Extension, 180°; flexion, 110°. X-ray shows firm union of graft.
A. H.	18	14 years	Left	Goldthwait	Torn medial meniscus removed 1 year previously	1 year	Slight quadriceps weakness. Active extension, 160°; passive extension, 180°. Position of patella, normal.
H. B.	39	20 years	Right	Goldthwait and reefing of internal capsule	Mass in quadriceps pouch removed 1 year previously (osteochondritis dissecans)	3 years	Slight tendency for lateral luxation of the patella. Extension to 175°; flexion to 100°. Crepitation, pain, and stiffness.
A. B.	25	5 months	Right	Goldthwait and reefing of internal capsule	Medial meniscus removed 3 months later	2 years. Last seen in 1929.	Very good. Position of patella, normal. Complete extension; flexion to 90°. Palpable crepitus, but knee painless.
M. S.	22	6 years	Left	Albee		7 years	Excellent
P. B.	7	3 years	Right	Albee		8 years	Excellent
E. D.	19	1 month	Left	Albee		9 years	Excellent
H. H.	16	2 years	Right	Albee	Manipulation 8 weeks after operation	4 years. Last seen in 1930.	Excellent. Slight periarticular swelling.
C. M.	19	4 years	Left	Albee and transplantation of tibial tubercle	Diseased medial meniscus removed. Manipulation 6 months after operation.	9 months	Excellent
J. T.	19	18 months	Both	Albee and transplantation of tibial tubercle. Left, 1 month following right.	Severance of abnormal transverse bands	14 months	Bilateral quadriceps weakness, but complete passive extension. Left knee shows some lateral instability. Partial recurrence of lateral displacement of both patellae. Patient feels that knees are "stronger".

N. D.	43	23 years. Acute signs, 1 month.	Both	Transplantation of tibial tubercle; reefing of internal capsule and plastic repair of external capsule (Mayer)	Torn medial meniscus on right removed. Left side repaired 1 month later with removal of an abnormally loose medial meniscus. Repair repeated more effectively on right in 4 months.	19 months	Excellent on both sides
C. V.	40	16 years	Left	Transplantation of tibial tubercle and reefing of internal capsule	Preceded by supracondylar osteotomy for severe knock-knee, with medial rotation of the lower fragment	3 years	Very good. Complete extension; flexion to 90°.
E. F.	23	10 years	Right	Transplantation of tibial tubercle and reefing of internal capsule	Removal of joint mice (synovial osteochondromatosis). Manipulation 5 months after operation.	2 years and 6 months	Excellent
E. D.	27	1 year	Left	Transplantation of tibial tubercle and reefing of internal capsule	Bone fragment from fractured medial tibial condyle removed	5 years	Excellent
E. L.	37	2 years	Right	Transplantation of tibial tubercle and Ober fasciaplasty		8 months	Excellent
M. R.	33	6 months	Right	Reduction of dislocation of patella and reefing of internal capsule	Fibrillated medial meniscus removed (organized clot in knee joint)	5 months	Excellent
H. H.	33	3 months	Right	Reduction of dislocation of patella and plastic repair of torn medial patellar retinaculum by reconstruction of medial patellofemoral ligament		2 years	Excellent
E. T.	31	3 years	Left	Reduction of dislocation of patella and plastic repair of torn medial patellar retinaculum by reconstruction of medial patellofemoral ligament	Partial resection of postpatellar fat pad	2 years	Excellent
M. B.	18	6 months	Left	Reduction of dislocation of patella and repair of torn medial patellar retinaculum by simple chromic sutures		1 year	Excellent

patella to the femur is constantly changing, thus throwing much strain on the fascial ligament, the relationship of the patella to the tibia is constant, and he modified the procedure described by anchoring the patella to the medial aspect of the upper end of the tibia.

The correction of the laterally dislocated patella was performed as a *secondary* procedure in two cases, where operations performed one year previously—the removal of a mass in the quadriceps pouch in one case and of the medial meniscus in the other—had failed to relieve symptoms. In five cases, the plastic repair was *followed* by secondary procedures,—the removal of an undiagnosed torn medial meniscus in one case three months later, a more efficient repair of the laterally dislocated patella in one case, and manipulations to increase the range of flexion in three cases.

Postoperative care consisted of immobilization in a plaster splint, a circular plaster bandage, or a brace (two cases) for from six to eight weeks, if the bone had been operated on, or for from two to three weeks if only the soft tissues had been repaired, followed by active mobilization, physiotherapy, and exercises.

The only complication was a case of tourniquet paralysis of two months' duration, with resultant foot-drop.

END RESULTS

Follow-up observation of the twenty patients varied from four months to nine years. Many have been recently examined, a few have been corresponded with. Three patients could not be contacted, but their follow-up records were sufficiently complete to indicate the end results.

In only two cases might the end results be considered unsatisfactory. In fifteen cases the results were excellent, the position of the patella was again normal, the range of motion was complete and painless, and the function of the knee was normal.

In one case (E. S.), operated on only recently (November 1936), the position of the patella is excellent, with a range of motion from complete extension to almost a right angle, despite the removal of plaster fixation but a few weeks ago (February 1937).

In the remaining two cases, the position of the patella is normal, and the stability of the knee is excellent, with painless motion and complete extension. Flexion is limited to 90 degrees, due to slight contracture of the quadriceps and the patellar tendon. Neither patient has attended the Clinic with regularity for postoperative physiotherapy, and it is felt that by more sincere cooperation these patients might well have enjoyed perfect results.

Of the two cases in which less satisfactory results were obtained, one was bilateral, probably of the congenital type, in which an Albee procedure and transplantation of the tibial tubercle had been combined. There is partial recurrence of the deformity, yet the patient feels that the knees are "stronger", and she is satisfied with the result. She no longer is subject to the repeated falls that she experienced prior to the operation.

In the other case, of traumatic origin, a Goldthwait procedure had been combined with a reefing of the internal capsule. There is slight recurrence of the lateral patellar luxation, some limitation of flexion and extension, slight pain, and crepitation in the involved knee. Many of these disabilities and symptoms might well be attributed to a concomitant osteochondritis dissecans noted at the time of operation.

CONCLUSIONS

The traumatic factor plays a prominent rôle in this condition. Two types of cases are noted: (1) the previously asymptomatic knee upon which has been imposed direct or indirect trauma, moderate or severe, and in which anatomical anomalies play little part; (2) the knee in which congenital or anatomical defects are prominent, with preexisting mild symptoms becoming aggravated by injury.

Associated injury to the intra-articular, capsular, and periarticular structures of the knee must be anticipated and adequately cared for at the same time as the plastic repair of the displaced patella, if complete relief is to be obtained and irremediable secondary changes are to be avoided.

Excellent results have been obtained in the main, irrespective of the type of operative manoeuver employed. The less satisfactory results do not reflect adversely, with consistency, on any one method.

The trend seems to favor the simpler extra-articular procedures which have proved so mechanically efficient, especially the medial and downward transplantation of the tibial tubercle, in whole, or in part as in the Goldthwait operation, and its attached patellar tendon, combining this, as may seem necessary, with medial capsulorrhaphy or a fasciaplasty of the Ober type.

However, the indications for the type of procedure or variation to be employed, depend entirely upon the nature of the individual case—whether it be of the congenital or of the pure traumatic type—and the associated pathological conditions present.

The Albee procedure is expressly indicated in those cases in which there is congenital deficiency of the lateral femoral condyle and the intercondylar sulcus.

An associated severe genu valgum must be corrected initially—for example, by supracondylar osteotomy—prior to any corrective measures on the patella itself. As in Case C. V., the osteotomy is combined with medial rotation of the lower fragment to bring the lateral femoral condyle forward, a procedure devised by Graser.

A marked hiatus in the lateral capsule, following the patellar reduction, may require such a plastic repair as was performed by Dr. Mayer in his case.

Finally, severe associated tears of the medial patellar retinaculum and patellofemoral ligament, as in some traumatic cases, require coincident plastic repair. This underlying pathological process must be borne in mind in every *acute* traumatic case, even after successful closed reduc-

tion, and the danger of recurrent luxation must be anticipated. In the case where reduction is impossible, open correction is essential, and the tears should be repaired by several layers of interrupted mattress and continuous chromic catgut sutures. This was done in the case of one patient, F. C., aged twenty-five, not included in this series, who dislocated the right patella five days prior to reduction.

The writer wishes to express his appreciation to Dr. Leo Mayer, Dr. Samuel Kleinberg, Dr. Harry Finkelstein, and Dr. S. A. Jahss for the unrestricted use of records from their respective Services at the Hospital for Joint Diseases. He is indebted to Dr. Henry Milch for permission to present his interesting cases.

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SUBCUTANEOUS SURGERY IN THE DISLOCATED HIP *

BY P. M. GIRARD, M.D., DALLAS, TEXAS

Recent reports [1,2] in the literature dealing with end results in congenital dislocation of the hip lead one to the opinion that, even though such a dislocation is reduced early, either by closed or by open methods, quite frequently poor results are observed when the patient grows older.

When closed reduction is done, there is a wadding up of that portion of the capsule between the hour-glass contraction and the acetabular rim into the acetabulum, anterior to the head.[4] (See Figure 2.) This produces irregular pressure upon the head from folds of the tough, firm capsule and prevents the head from sinking deep into the acetabular cavity. Under these circumstances, the rim of the acetabulum also produces pressure upon the head. Open reduction, with release of the hour-glass contraction, has not proved to be the solution of this problem, because of the disturbance in circulation about the joint and the inevitable formation of excessive scar tissue, which always produces shortening and tightening of the capsule and adjacent muscles. This produces varying degrees of stiffness of the hip joint with poor end results.

In an attempt to circumvent the above objections to closed and open reduction methods, subcutaneous section of the hour-glass contraction was done first in 1935. This procedure has now been done in eleven cases, and has been successful in all but three,—one thirteen-year-old girl, one ten-year-old girl, and one patient with a large bifurcated femoral head.

TECHNIQUE

An incision, approximately two centimeters long, is made just above and slightly anterior to the greater trochanter and parallel to it. The fibers of the gluteus maximus are separated by blunt dissection with artery forceps. (See Figure 3-A.) The anterior portion of the capsule is punctured, and the hour-glass contraction is palpated with the end of the forceps. The dense contracted portion of the capsule is grasped by the Ochsner forceps. A scalpel is passed along side of the forceps, and the constriction is cut, three slits being made. (See Figure 3-B.) The dislocated head is then reduced by manipulation and held by a plaster cast. The hour-glass contraction slips over the head, permitting the head to enter deeply into the smooth acetabular cavity. (See Figure 4.)

If the head cannot be reduced without undue stress and strain, subcutaneous section of the adductor tendons is done, and the manipulation is again attempted. If this manoeuver is unsuccessful, a subcutaneous section of the muscles attached to the anterior superior spine is next done. Passing a cartilage knife subperiosteally around the greater trochanter

* Read before the Orthopaedic Section of the Southern Medical Association, Baltimore, Maryland, November 18, 1936.

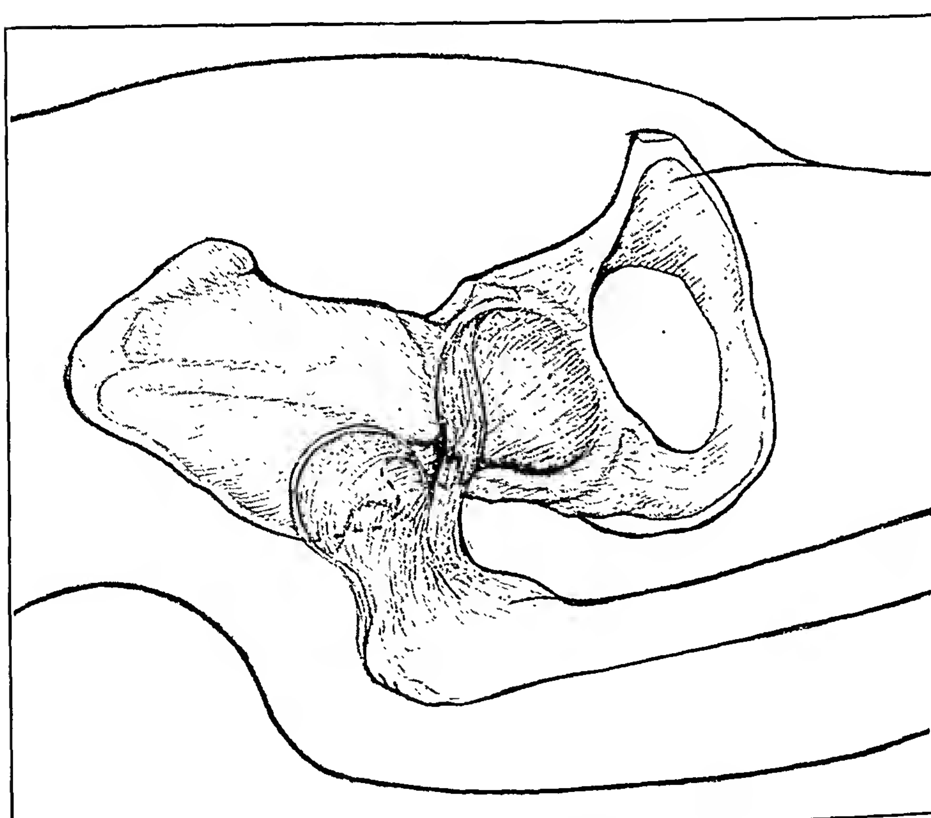

Fig. 1

Diagram of an hour-glass contraction in the capsule of a congenitally dislocated hip.

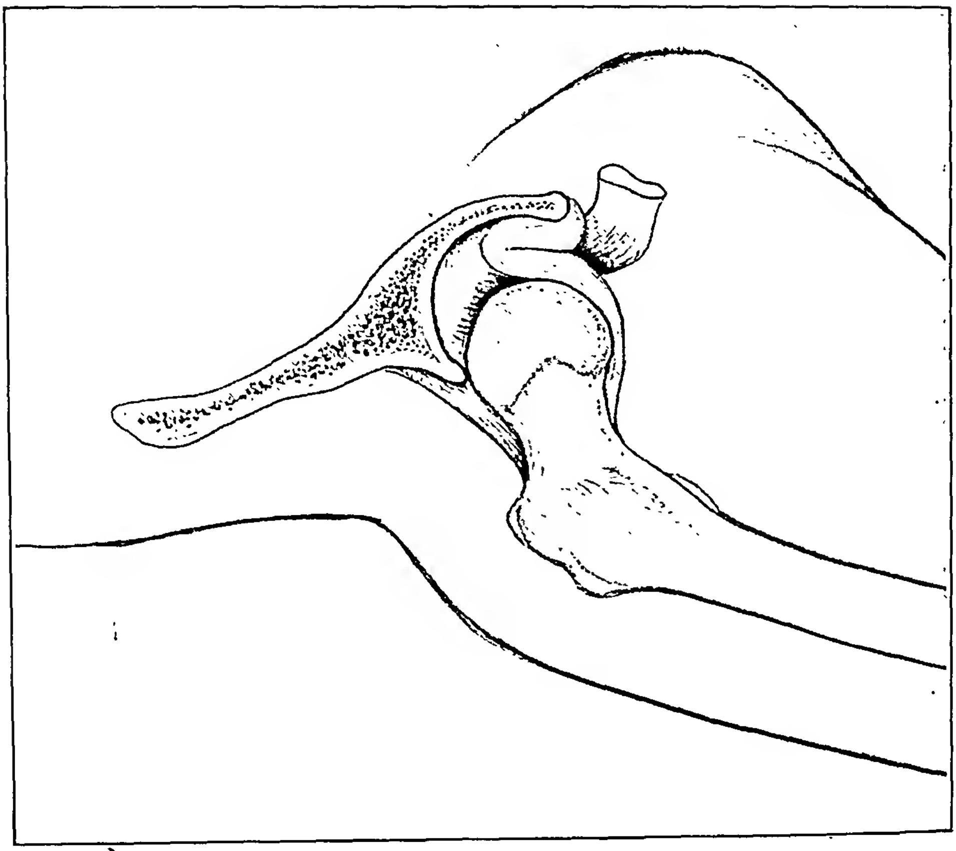

Fig. 2

Diagram showing the folding of the hour-glass contraction into the acetabulum when closed reduction is done.

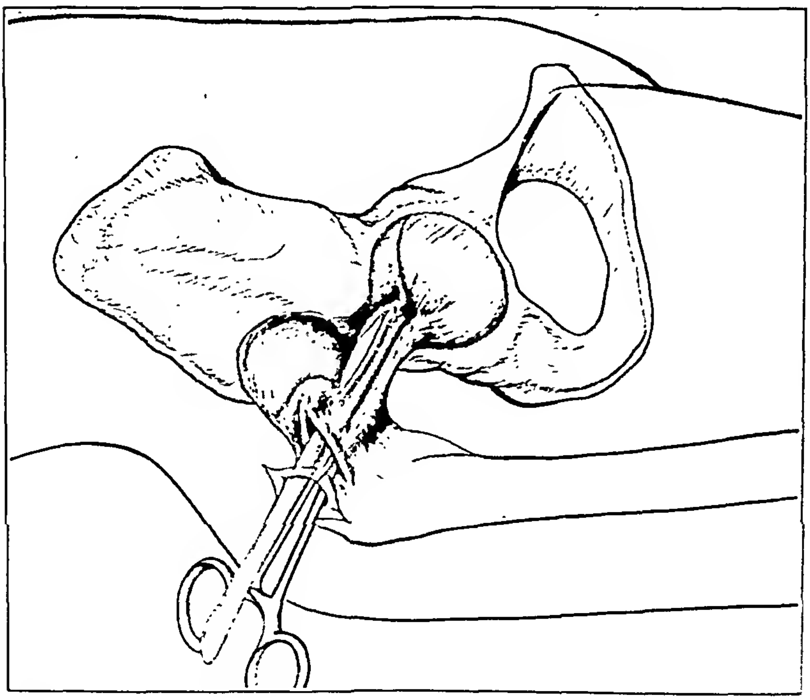

Fig. 3-A

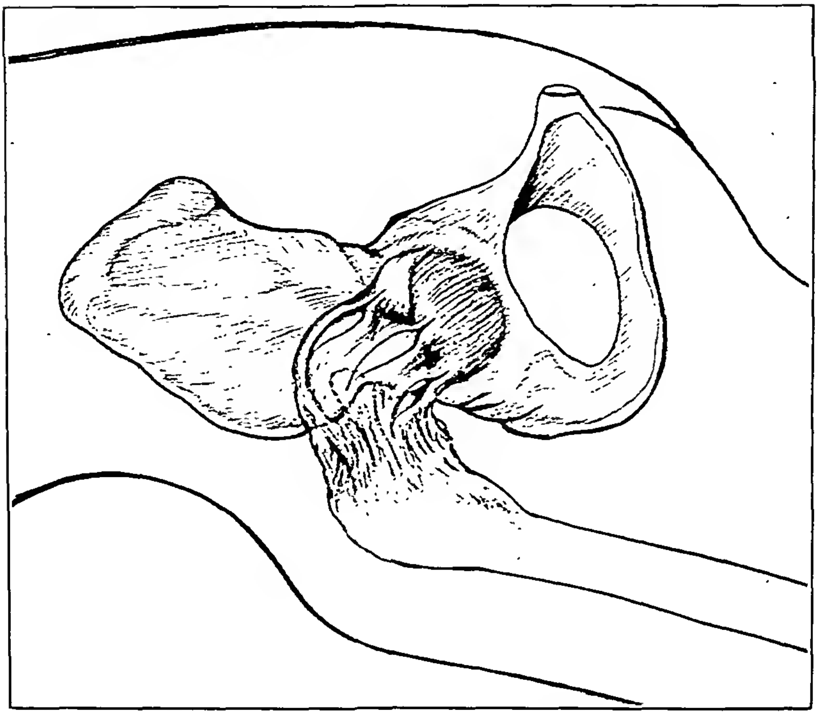

Fig. 3-B

Subcutaneous sectioning of the hour-glass contraction.

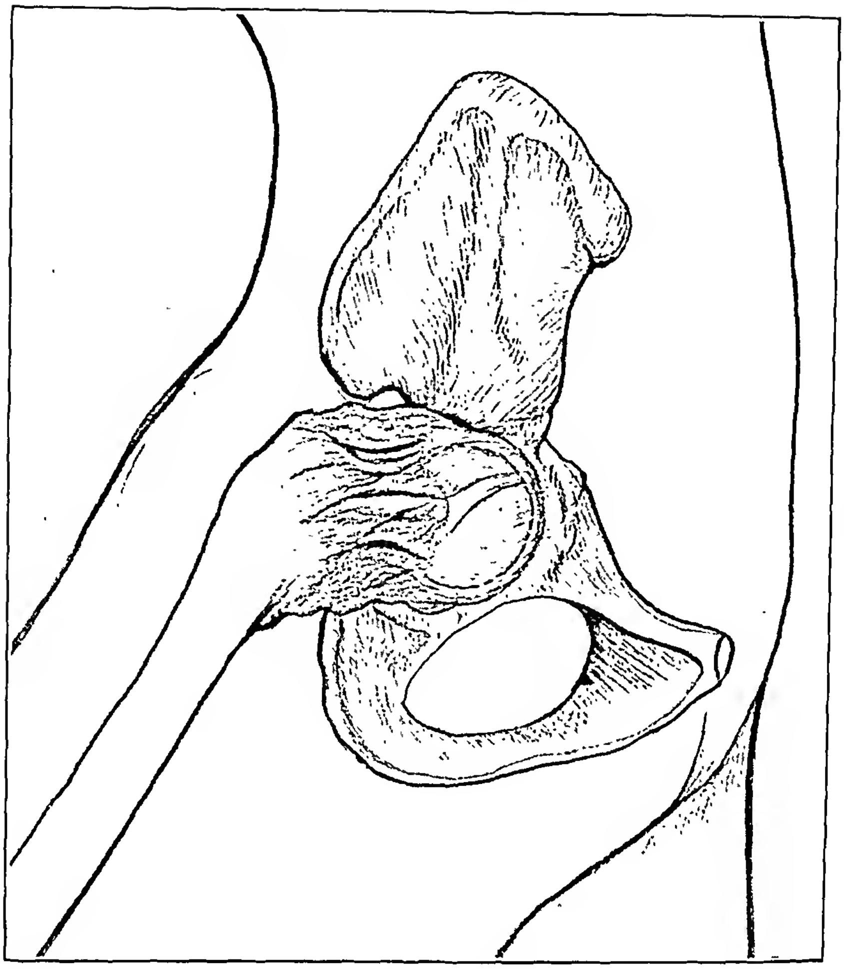

Fig. 4

The hour-glass contraction slips over the head as reduction is accomplished. This permits the head to enter deeply into the smooth acetabular cavity.

releases the glutei. This proeedure is done subeutaneously through the original ineision. If a third attempt at reduetion fails, a Kirschner wire is passed through the eondyles of the femur, and heavy skeletal traction is applied over a Braun-type splint, elevating the foot of the bed for additional eountertraction. (See Figure 5.)

In from ten to twenty days, roentgenographie examination usually shows the head redueed or resting on the rim of the aeetabular eavity. (See Figures 6-A, 6-B, and 6-C.) Medial traetion, obtained by passing a band around the upper third of the leg, may accomplish reduetion. In one ease a gentle manipulation was done under gas anaesthesia, and reduetion was aeeomplished at this stage.

After reduetion, the hip is held in the abduetion position in a east for three months. Following the removal of this first east, the hip is brought down to a 45-degree position and held by a single hip spiea, extending from the ribs to the knee; ineorporated in the east is a single-bar, knee-joint, ealiper braee. (See Figures 7, 8-A, and 8-B.) The purpose of the brace is to prevent fraeture. In this apparatus weight-bearing is allowed.

A remarkable finding in these eases has been the relatively free motion (45 to 75 degrees) present in the hips when the first east is removed three months after reduetion. When the position is considered unstable, a subeutaneous shelf operation may be done at the time of reduetion or later. The teehnique followed in doing this operation is that reported by Spitzy.[3]

Fig. 5

Kirschner-wire traction and medial traction after subcutaneous release at the hip.

CASE REPORTS

Case 1. J. B., male, six years of age, with congenital dislocation of both hips.

In January 1936, subcutaneous section of the hour-glass contraction of the capsule of one hip, together with subcutaneous section of the adductors, was done, but it was impossible to reduce the dislocation. Traction by Kirschner wire through the condyles of the femur, and traction by wire and medial traction by band around the thigh for eighteen days resulted in automatic reduction.

The patient is wearing a brace and has excellent motion. At a later date, similar treatment will be given the opposite hip.

Case 2. M. L. B., female, aged four years, with congenital dislocation of the left hip.

In July 1936, subcutaneous section of the hour-glass contraction was done, but reduction was unsuccessful. Subcutaneous section of the adductors was also done, and reduction was again unsuccessful. Traction by Kirschner wire through the condyles of the femur and traction for twenty days with added medial traction resulted in automatic reduction of the head.

The patient had 45 degrees of motion when the first cast was removed. She is now walking without any apparatus. The hip is in excellent conjugation.

Case 3. A. B. A., female, aged nine years, with congenital dislocation of the left hip.

In April 1936, subcutaneous section of the hour-glass contraction of the capsule failed to effect reduction. Section of the adductors was then done, but reduction was unsuccessful. Traction with Kirschner wire through the condyles of the femur for three weeks was also unsuccessful as far as reduction was concerned.

In May 1936, a gentle manipulation was done under gas, and the dislocation was reduced satisfactorily and easily. Ten months later, a double wing back shelf operation was done. The head was in the acetabular cavity, but was skidding upward on the markedly oblique upper acetabular rim.

Case 4. B. L. H., female, thirteen years old, with congenital dislocation of both hips.

FIG 6-A
Case 1. Bilateral congenital dislocation of the hip.

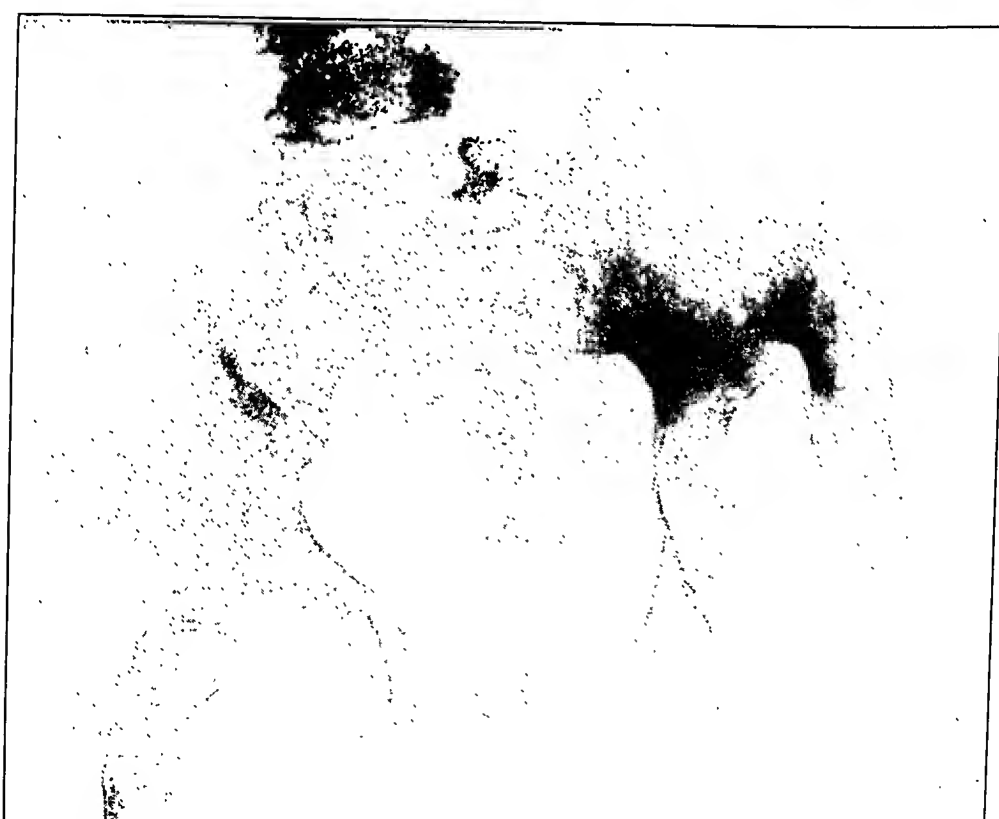

FIG. 6-B
Case 1. Roentgenogram showing the head resting on the rim of the acetabulum under heavy skeletal traction.

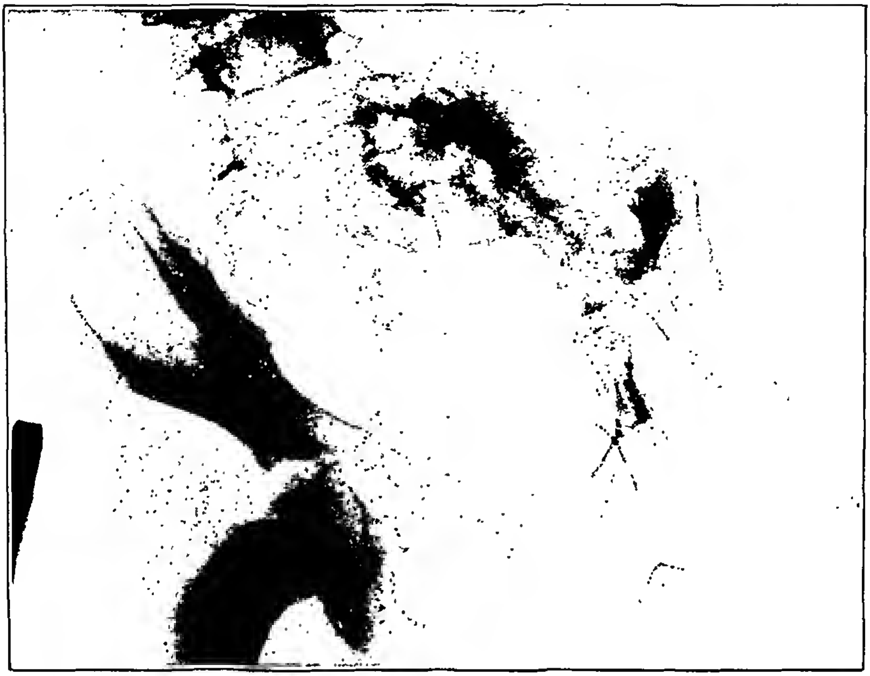

Fig. 6-C

Case 1. Roentgenogram showing head reduced after medial traction was added.

Subcutaneous section of the hour-glass contraction of the right hip and manipulation failed to accomplish reduction. Section of the adductors, of the tensor fasciae latae, and of the glutei was done, and Kirschner-wire traction was applied for three weeks. This, with medial traction, was unsuccessful. Manipulation under gas was also ineffectual; therefore, open reduction was done. The head did not remain in the cavity; consequently, seven months later, an open operation, with the shelf of the right hip in position above the acetabulum, was done. At a later date, a shelf operation will be done on the left hip, with the shelf at the same level as that of the right hip.

Case 5. H. T., male, five years of age, with congenital dislocation of the right hip.

In June 1935, subcutaneous section of the hour-glass contraction was done, resulting in immediate reduction. Reduction was accomplished prior to subcutaneous section of the capsule, but the head was not very stable. After section of the capsule, the head of the femur sank deeply into the acetabulum and was quite stable.

To date, the functional result is excellent.

Case 6. M. W., female, aged four years, with congenital dislocation of the left hip.

In September 1935, subcutaneous section of the hour-glass contraction of the capsule brought about immediate reduction.

Case 7. B. H., male, aged eight years, with congenital dislocation of the left hip and a congenital cleft lip and palate.

In July 1936, tonsillectomy and adenoidectomy were done in preparation for closure of the palate by a nose and throat surgeon. Subcutaneous section of the hour-glass contraction of the capsule and of the adductors resulted in immediate reduction. (All of these operative procedures were done under the same anaesthetic.)

The patient at present is in a walking apparatus. Before this apparatus was applied, there was motion in the hip amounting to 50 degrees.

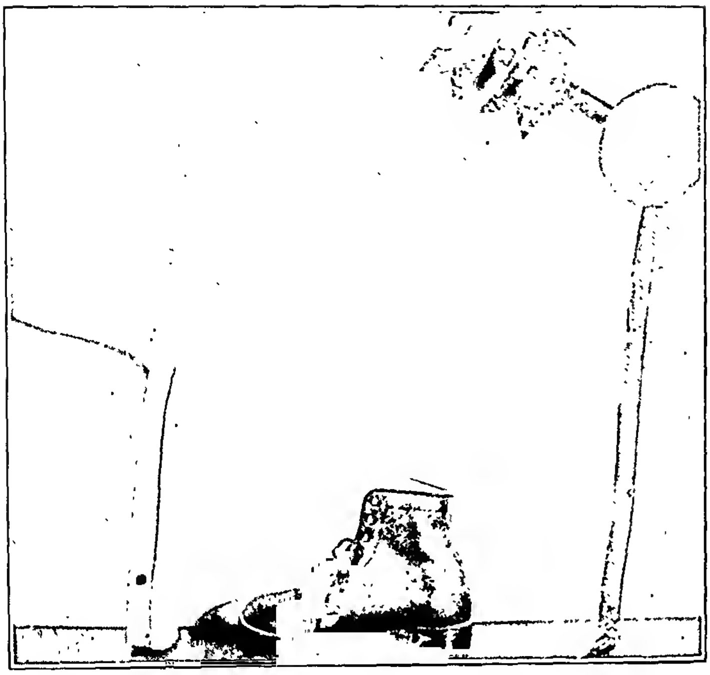

Fig. 7

Showing brace for the prevention of fracture. Foot rest for bed wear.

Fig. 8-A Fig. 8-B

Cases 7 and 8. The patients are wearing abduction plasters with braces incorporated. This apparatus is worn for three months.

Case 8. D. S., male, five years old, with congenital dislocation of the left hip.

In June 1935, open reduction was done after an attempted subcutaneous section of the hour-glass contraction failed. Open inspection revealed a large, partially bifurcated head of the femur which was too large to enter the acetabulum. The size of the head was decreased by removing some of the wide portions of the head, and reduction of the dislocation was accomplished.

In September 1936, the head was again subluxated. The patient had suffered a fracture in the upper end of the tibia with malposition. An osteotomy was done through the old fracture site to correct alignment of the tibia, and a graft was removed from the upper half of the tibia for a subcutaneous shelf over the subluxating hip.

Examination on May 5, 1937 showed that the left hip skidded upward slightly, but was stable when the patient walked.

Case 9. P. J. F., female, aged one and one-half years, with multiple congenital anomalies: bilateral club-hand and club-foot, flexion of the wrists, and bilateral dislocation of the hip.

On January 11, 1937, subcutaneous release of the hourglass contraction of both hips resulted in immediate reduction. The patient is still under observation in plaster fixation, with the hips in good position.

Case 10. T. E. C., male, one and one-half years of age, with multiple congenital

deformities: a rudimentary right foot, deformity of the left leg due to amniotic-band contraction, left club-foot, spina bifida occulta at the fifth lumbar vertebra, and dislocation of the right hip.

On February 19, 1937, an unsuccessful attempt to reduce the dislocation by manipulation was made. Subcutaneous release of the hour-glass contraction resulted in immediate reduction.

The patient is still in plaster fixation.

CASE 11. E. K., female, aged ten years, with congenital dislocation of the right hip. No treatment had been given.

On April 16, 1937, subcutaneous release of the hour-glass contraction, of the adductors, of the tensor fasciae latae, and of the glutei at the trochanter was done. Traction by Kirschner wire through the condyles of the femur with lateral traction by band over the greater trochanter was applied for three weeks.

On May 7, 1937, attempted manipulation was unsuccessful, and the head of the femur was still above the rim of the acetabulum. The hip was fixed in plaster, and a shelf operation will be done later.

COMMENT

In cases of congenital dislocation of the hip, a subcutaneous section of the hour-glass contraction of the capsule described affords release of the contraction with a minimum of surgery. Both hips may be operated upon simultaneously by this method. Obviously, no end results can as yet be reported.

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FIG. 1

Early slipping of the femoral epiphysis of the right hip. Note the disappearance of the slight bulge of the right head, the slight prominence of the neck just distal to the epiphyseal line, and the slight broadening of the epiphyseal line.

Pomeranz and Sloane, in 1935, made a thorough study of 120 or more cases treated at the Hospital for Joint Diseases. They found that in those cases in which extensive displacement had occurred and fixation in the deformed position had ensued the results were bad in all but two or three instances. This was true irrespective of the nature of treatment,

Right Left

FIG. 2-A FIG. 2-B

Lateral views showing early slipping of the femoral epiphysis of the right hip. Note the displacement of the head in a backward and downward direction.

FIG. 3-A

FIG. 3-B

Early slipping of the femoral epiphysis which was treated by abduction in bed (case of Dr. L'Episcopo). Slipping occurred as shown in Fig. 3-B while patient was immobilized in traction.

whether manipulative or operative, and at least seven different operations had been attempted. The bad results of manipulation in the later stages were also stressed by Key in his masterly article on the subject. Pomeranz and Sloane found on the other hand that when the diagnosis was made in the early so-called preslipping stage and treatment was carried through until ossification of the epiphyseal plate had occurred the results were uniformly good.

What are these early changes? If we study roentgenograms of normal children, we note that the hemispherical head casts a bulging shadow at its junction with the upper margin of the neck. This lies just proximal to the oblique line, indicating a lighter shadow caused by the

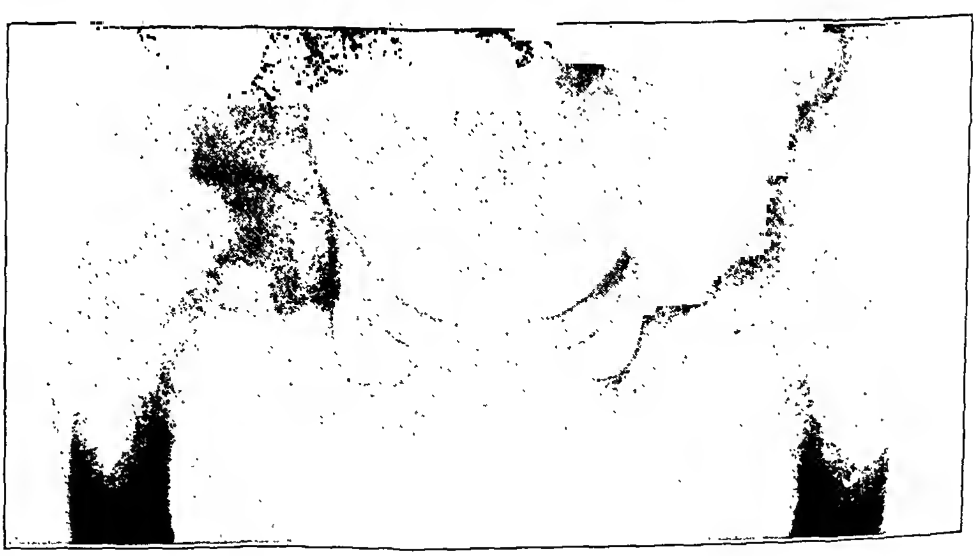

FIG. 4

Fusion of head to neck secured by implantation of a tibial bone graft.

epiphyseal plate. The first sign of slipping is the disappearance of this slight bulge and conversely the appearance of a slight prominence of the upper margin of the neck. (See Figure 1.) These roentgenographic changes are due to a combination of two motions which appear to occur synchronously,—namely, a forward displacement of the neck (an anteversion which Milch has taken pains to emphasize) and a slight downward and backward displacement of the head. Because of this, the vertical diameter of the head becomes slightly diminished. In many cases we also see a broadening of the epiphyseal line, no doubt due to the changed projection caused by the slipping. In the lateral view of the head, the downward displacement of the capital epiphysis is usually well seen. (See Figures 2-A and 2-B.)

Corresponding to these roentgenographic changes are characteristic physical signs. These have already been referred

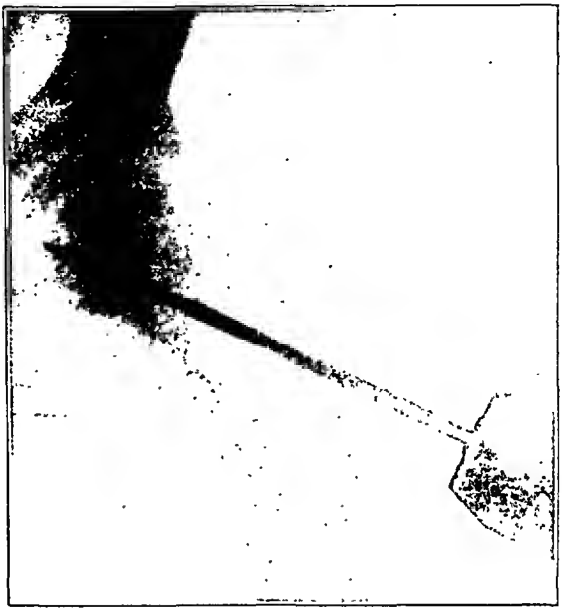

FIG. 5-A

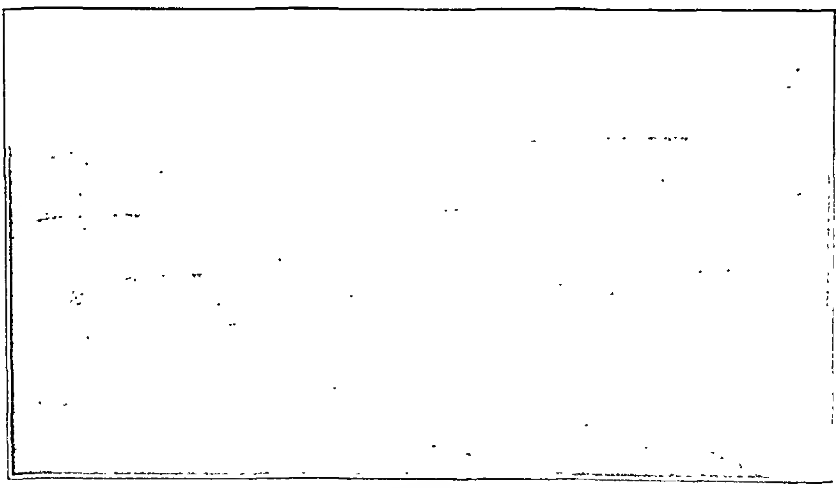

FIG. 5-B

Anteroposterior and lateral views of drill about to penetrate the epiphyseal cartilage.

FIG. 6
The same case as in Figs. 1, 2-A, and 2-B three months after the drilling operation. Note that the head has become firmly fused to the neck.

to,—namely, a slight limitation of internal rotation and of abduction. Limitation of internal rotation is best demonstrated by flexing both hips and internally rotating both thighs at the same time. This prevents any compensatory motion of the pelvis which might confuse the observer. There is rarely any limitation of flexion or extension. The limitation is usually slight and it may disappear if the patient rests in bed for a few days. There is little or no tenderness and no swelling. In other words, the objective symptoms are so slight as to be misleading unless one understands their significance.

The term "preslipping" is a misnomer and should be discarded because from the outset a slight degree of slipping is present and forms the basis for both the characteristic roentgenographic changes and the physical signs.

If the diagnosis is made in the early stage, a number of methods may be employed which, in our experience, have given excellent functional results. The essential principle of all these methods is fusion of the head to the neck by replacement of the cartilaginous epiphyseal plate with bone. In some instances, particularly in older children, simple fixation of the leg in plaster-of-Paris in a position of abduction and external rotation is sufficient for this purpose. This method, however, has its limitations; a long period of time is frequently necessary and L'Episcopo has demonstrated a slipping which occurred in one of his patients while this method was being carried out. (See Figures 3-A and 3-B.) Far more effective are the operative procedures. The head can be fixed to the neck

by means of a Smith-Petersen nail, a bone graft, or wire screws such as are used for the fixation of a femoral-neck fracture. Figure 4 illustrates the solid fusion secured through the use of the tibial bone graft.

Jahss has traumatized the epiphyseal plate by hitting the trochanter a sharp blow with the Cotton mallet. In his series of cases, fusion resulted in all without evidence of arthritic changes in the bone.

The author's own preference has been the drilling method first instituted in this country by Bozsan and Telson. In this technique the leg is first manipulated, so as to secure full range of external rotation and abduction. A three-inch incision, extending from the trochanter downward on the outer side of the femur, is then made. The subtrochanteric region is exposed and a hand drill is inserted in the direction of the femoral neck. Control roentgenograms are taken both in the lateral and anteroposterior views to determine the accuracy of the location of the drill. (See Figures 5-A and 5-B.) When it is certain that the drill is aimed directly at the epiphyseal plate, it is advanced until the plate is perforated. This procedure is repeated at seven or eight different points. The leg is then immobilized in plaster-of-Paris in a position of abduction and external rotation. This spica is left in place for ten weeks. At the expiration of this time, control roentgenograms are taken to determine whether the epiphyseal cartilage has been replaced by bone. If so, the patient is allowed to begin walking; if not, plaster is reapplied and kept in place until fusion is visible roentgenographically. (See Figure 6.) In no case has this required more than four months. The average period has been three months. About twenty cases have been treated by this method; in all of them in which the diagnosis was made early when the slipping was extremely slight, the result has been normal function of the hip and a perfect gait.

SUMMARY

Early diagnosis is the key to successful treatment of slipping of the upper femoral epiphysis. The diagnosis can be made with certainty from the history, the physical signs, and the characteristic roentgenographic picture. Treatment should be instituted at once and should be carried through until bony fusion has occurred between the head and the neck. This can be secured by either a Smith-Petersen nail, or a bone graft, or bone screws, or impaction, or the drilling method.

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PHYSIOLOGICAL CONSIDERATIONS IN THE TREATMENT OF FOOT DEFORMITIES

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Because of its design, the foot has long been recognized as a specialized organ for man's upright carriage of his body. Its unique morphology means, therefore, that the foot possesses a specific and localized range of function which qualifies it as a distinct physiological unit in the general phenomenon of locomotion.

If only a single block of bone were positioned beneath each leg to serve as a foot, locomotion would be very much of a peg-legged performance, and little opportunity would be given for local physiological study except for such facts as pertain to the normal interactions and relationship between that single bone and the leg. But nature has fashioned a far more efficient structure for a foot, and in its complexity of design and parts has implanted a specific sphere of physiological activity. Like the eye, the foot is an end-organ, both being terminal structures of their respective visual and locomotor systems. In one case, the eye with its lens is designed to transmit light rays from outside onto the retina, so that clearly defined image-impulses are relayed to the brain by the intervening nerve channels. Similarly, the foot with its supporting framework is designed to divide and to transmit body weight received upon the talus from the leg bones to various points of ground contact in accordance with a definite ratio of distribution. Thus, just as refraction of light rays within the eyeball is a distinct and localized entity in the complete phenomenon of sight, so the ordered division and transmission of stresses between the ankle and the ground characterizes the specialized function of the foot.

The *distribution*, *course*, and *intensity* of those stresses, as influenced by gravity and propulsive effort, comprise the intimate sphere of foot "physiology". It must be distinguished from the correlationship between foot and leg,—the adjacent phase of locomotion which is centered upon the ankle. Both are so closely associated, however, that disturbance in one is immediately reflected upon the other. As a result, the more visible signs of disordered relationship at the ankle have caused this phase to receive attention so predominantly that the importance of what takes place *inside* the foot has largely been left in obscurity. Actually, recognition of an internal physiology of the foot leads to clearer identification and localization of causative factors in foot disorders, and offers most promising opportunities for their study and treatment along physiological lines which so far have not been developed.

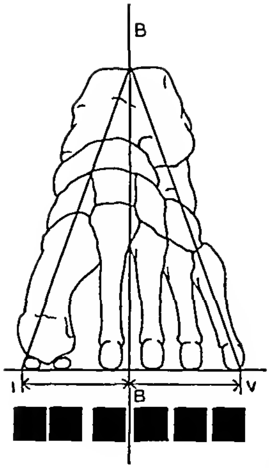

FIG. 1

Normal foot posture and weight distribution in stance. The ratio of 2, 1, 1, 1, 1 is represented in the equal-sized black squares.

BB: Vertical plane of balance.

IB and *BV:* Medial and lateral margins of structural stability.

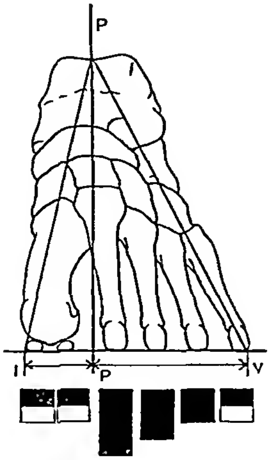

FIG. 2

Mild pronation. Note concentration of weight on the second metatarsal.

PP: Vertical plane projected from centers of ankle and heel contact.

IP: Reduced medial margin of stability.

PV: Lateral margin.

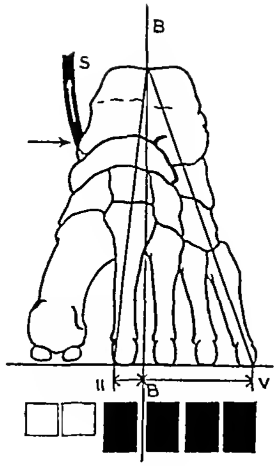

FIG. 3

Pronation corrected by supinator action. (Compare with Fig. 1.) Note non-contact of the first metatarsal and difference in weight distribution; also the reduced medial margin (*II-B*) of structural stability.

S: Supinator muscles exerting lateral pressure against foot to sustain corrected posture.

Staticometric tests described in full elsewhere[2], have shown that in stance the ratio of weight distribution to the heel posteriorly, and to the five metatarsals anteriorly, conforms closely with the formula 6: 2, 1, 1, 1, 1. The metatarsal portion (2, 1, 1, 1, 1) of the formula is of special importance, because the ratio prevailing in stance predetermines the comparative load on each metatarsal bone when all the stresses are projected upon the forepart of the foot in locomotion. Also, for its significance in clinical disorders, the following statement should be added: With any existing variation in that ratio, the differences are multiplied in locomotion according to the strength of the propulsive effort.

One of the most common sources of pronation deformity is found in the laxity of the ligaments of the first metatarsal segment. This laxity deprives that member of its normal supporting contact, so that the foot rolls inwardly until ground contact is gained by this bone. If the defect is of moderate degree, the ratio may be altered from 2, 1, 1, 1, 1 to 1, 2, 1.5, 1, 0.5 (Figs. 1 and 2). Weight is concentrated on the second metatarsal, because it must serve as the pivot for pronation until the first metatarsal comes in contact with the ground.

If a patient with such feet is told to elevate the inner borders by voluntary muscular effort, the faulty posture can be overcome easily. This gives the feet a normal appearance morphologically, but physiologically the conditions are by no means corrected (Fig. 3). The first

metatarsal has been lifted from supporting contact with the ground and its share of body weight has been transferred upon the four lateral metatarsals; also the medial stability of the foot—now supplied by supinator effort—will be continued only so long as the muscles can sustain their voluntary contraction. In this condition, the cause is primarily *intrinsic*, being located within the foot structure; the postural effect upon the ankle is secondary.

In contrast, a paralytic weakness of the supinators in a hitherto normally balanced foot gives a different disturbance in ratio. As pronation develops through loss of muscle balance, body weight is concentrated directly on the first metatarsal until the intensified stresses and their distorted movement break down the inner border of the foot. Here the primary cause is *extrinsic* as the affected muscles lie above the ankle, and the foot's mechanism is affected secondarily. Short calf muscles are another extrinsic factor, which also concentrate weight stresses directly upon the inner border of the foot and the first metatarsal, in producing pronation deformity.

These examples indicate very simply how physiological considerations in weight distribution are applicable to clinical studies. In severe deformities their application is more complicated, but correspondingly more valuable, because extensive remodeling of the framework of the entire foot may be required. Consequently, familiarity with the functional value of each structural unit will be useful in devising with precision the most effective plan of treatment.

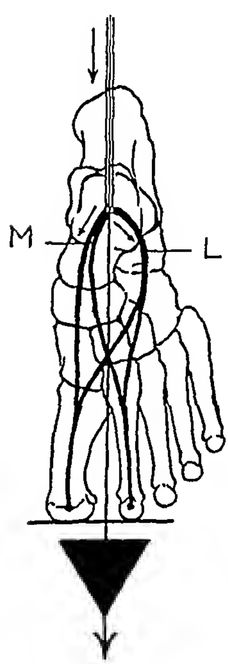

FIG. 4

Divergence of the medial (M) and lateral (L) movements of stress for counterbalance on the leverage axis (long arrow) of the foot.

In an extreme case of congenital talipes equinovarus, weight stresses are directed entirely upon the fifth metatarsal bone whose lateral side alone gives the foot its single point of contact with the ground. Graphically, it presents the very unbalanced ratio of 0, 0, 0, 0, 6.

There is one structural feature in the foot whereby weight stresses are initially separated into two anterior channels (Fig. 4) in order to create normal balance; it consists of a mild downward and inward slant of the sustentaculum tali. The degree of slant determines the proportion of stresses which

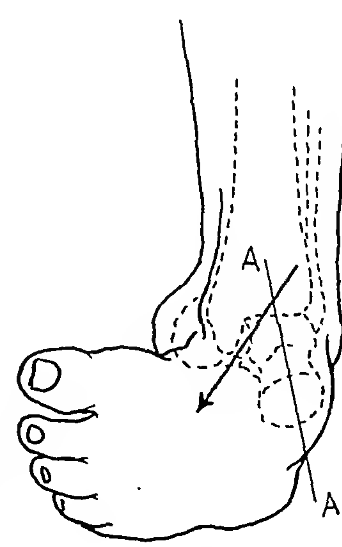

FIG. 5

Congenital talipes equinovarus, showing supination with its inversion of the calcaneum. The axis of the talus (AA) should normally be in line with the arrow to ensure proper weight distribution through the forepart of the foot.

are directed toward the medial side of the foot, and concurrently it controls the angle of deviation which the axis of the talus bears to the axis of the foot. In fact, this shelf-like process of the calcaneum may logically be viewed as the center of the foot's balancing mechanism. When its downward slant is increased beyond normal (as in pronation, flat-foot) body weight is more heavily thrown upon the inner border of the foot, and the medial deviation of the talus is widened (inward rotation).

In club-foot the opposite condition prevails. The supination element of deformity, emphasized so strongly by Kite, holds the calcaneum so inverted that the sustentaculum tali slants *upward*. As a result, all weight stresses are deflected toward the lateral border of the foot and, helped by the varus deformity, the talus is obstructed and held in a position where its axis deviates *laterally* to the foot's axis. Thus, physiological analysis reveals the vital importance of overcoming completely the inversion deformity of the heel in order to obtain normal balance for the foot, and designates the position of the talus as a valuable index to the necessary degree of correction. Elimination of varus and subsequently of the equinus deformity are also important steps in treatment, but these elements are so apparent morphologically that their correction has more generally conformed with physiological requirements.

Limited space prevents more extensive discussion of the application of these physiological principles. Their value can be more fully appreciated and developed only by use. In representing conditions of normal foot function, the formula 6: 2, 1, 1, 1, 1 supplies a fixed criterion toward which all corrective measures may advantageously be aimed. Although the formula submitted was obtained by means of specially designed apparatus, there are physical signs revealed in posture, in thickening of the skin under the metatarsal heads, and in roentgenograms, which identify quite effectively departures from normal weight distribution, as follows:

1. *Posture.* In the normally balanced foot, a vertical plane passes through the centers of the heel and ankle and is projected forward between the second and third metatarsals, thus dividing the entire load into equal longitudinal halves (2, 1) (1, 1, 1). (See Figure 1.) Any change from normal posture causes an inevitable distortion in the metatarsal ratio.

2. *Callus Formation.* In adults, examination of the texture of the skin across the metatarsal region of the sole is a very reliable test. Any uneven distribution of a heavier texture, ranging from a mild thickening to a marked callosity, is direct evidence of an overload on the corresponding metatarsal bone or bones.

3. *Roentgenograms.* In the dorsoplantar view of a foot with ideal design, the four lateral metatarsals have the same diameter of shafts and cortical thickness. Widening of the shaft and thickening of the cortex (most frequently affecting the second metatarsal) are positive signs of abnormally increased burden and strain. Lessened develop-

ment may be observed in the other metatarsals whose burden has been correspondingly reduced.

Modern strides in all fields of medicine have been based upon advances in physiology rather than in morphological knowledge. Moreover, just as the great majority of visual disturbances are due to disorder or defects in the eye as the peripheral organ, so the most common site of disorder in the locomotor system is its terminal structures—the feet. It would seem, therefore, that inestimable benefits might attend full recognition of the *internal physiology of the foot* and its inevitable relation to those disorders and their treatment.

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CHIP GRAFTS IN ORTHOPAEDIC SURGERY

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Without entering into any discussion of the merits of the various operative procedures employed by others for bone fusion, the author wishes to call attention to the wide range of usefulness of chip grafts. The cases presented herewith have been followed long enough to demonstrate the certainty of fusion by the author's methods. They illustrate the ease with which fusion may be obtained by chip grafts whenever strength of graft is not needed for fixation.

For the past eleven years the author has employed the multiple chip-graft method of spinal fusion as reported in 1932, and the results have been uniformly satisfactory. The detailed operative technique was presented in 1933 after having been successfully employed in over seventy-five cases. Liebolt's recent review of mortality statistics in orthopaedic surgery indicates that surgical shock is still a frequent cause of death, and that it is most common in extensive spinal fusions. There has been no death from surgical shock in spinal fusions by the chip-graft method in any of our cases. Six to eight vertebrae can be fused together easily and safely in an

FIG. 1

Healed tuberculous spine, eighteen months after operation.

FIG. 2

Recurrent back strain, three months after operation.

FIG. 3

Structural scoliosis, ten months after operation.

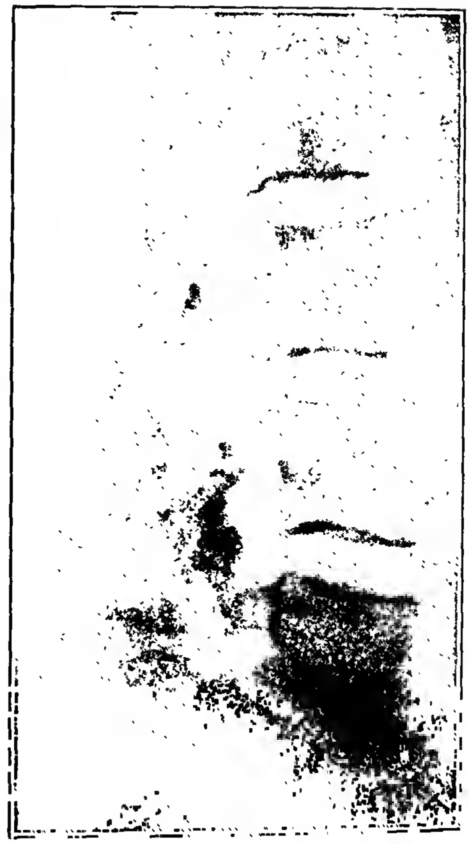

FIG. 4

Spondylolisthesis, two years after operation.

FIG. 5

Eight weeks after Dickson roofing operation for old congenital dislocation of the hip.

hour or less by using a second operating team to remove the chips from the tibia. The laminae are prepared first by scraping with a blunt osteotome, and then by raising thin cortical shavings from them with a hand chisel, which eliminates the shock of hammering upon the spine. The risk of fat embolism is considerably reduced by removing only osteoperiosteal and cortical chips from the tibia without opening the medullary cavity. "Bone marrow is the common source of the fat which gives rise to fat embolism" as Harris has shown, and the use of spongy bone with this additional risk is unnecessary. (See Figure 1.)

The great advantages of chip grafts are that they are always handy, that almost any quantity is available,

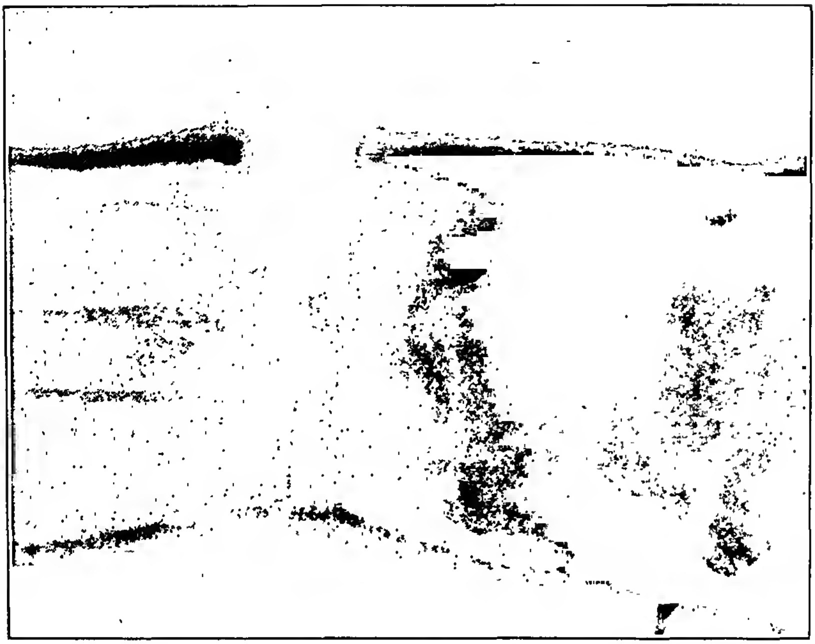

Fig. 6-B
Opening osteotomy of the tibia.

Fig. 6-A
Opening osteotomy of the femur.

Fig. 7-A

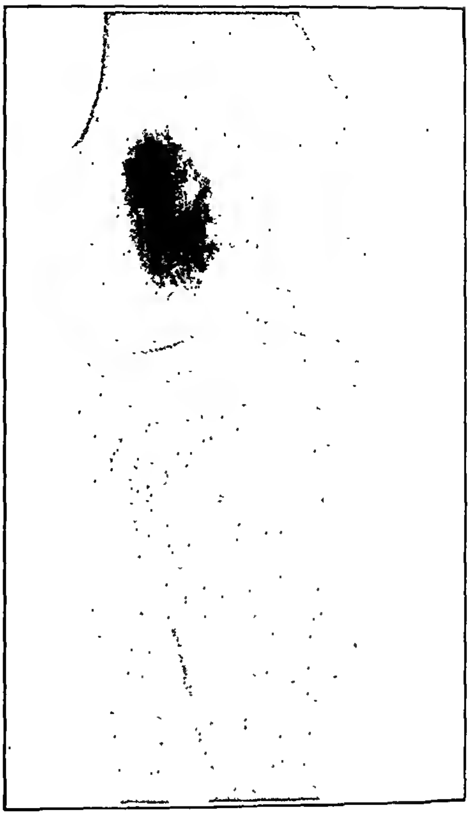

Fig. 7-B

Giant-cell tumor of the tibia, three months after operation.

and that no special apparatus is needed for their removal. Grafts larger than the fingernail are unnecessary and interfere with the close coaptation between grafts which is needed for good fusion. Chip grafts are probably revascularized more easily than large grafts, and they may be absorbed if not in close contact with the host and with each other. In the presence of complicating sepsis, of course, they die and are extruded. In none of the author's cases has a graft necrosed or sequestrated, unless sepsis intervened.

The amount of new bone formation is important in old compression fractures, in spinal tuberculosis, in lumbosacral fusions (Fig. 2), in scoliosis (Fig. 3), and in spondylolisthesis (Fig. 4) where the fused area will ultimately be subjected to considerable strain. If necessary, both tibiae can be used and massive fusions produced which eliminate the danger of "fracturing the graft".

In the arthrodesis of large joints, bone fusion is augmented and hastened by the use of chip grafts. In fusing the hip, knee, ankle, or shoulder, enough chips can usually be borrowed from adjacent exposed bones to fill tightly the remaining cavities. The Campbell operation for arthrodesis of the sacro-iliac joint can be strengthened by additional tibial chip grafts. The Dickson roofing operation for congenital dislocation of the hip may be simplified by turning down flaps from the ilium, reflecting the entire acetabular roof downward, and then packing additional

tibial chips in tightly behind the flaps to hold them in position anteriorly and posteriorly, as well as superiorly.

In corrective osteotomies of the lower extremities, union is hastened and length is gained by opening the transverse osteotomy and filling the gap with chips. (See Figures 6-A and 6-B.) The use of bone chips and osteoperiosteal grafts to augment inlay grafts in osteosynthesis of the long bones is well known; they furnish osteogenic material for earlier union while the massive graft furnishes fixation.

In the surgical treatment of certain bone tumors, such as cysts, giant-cell tumors, osteitis fibrosa, and benign types of chondrosarcoma, bone chips are increasing in popularity. (See

Fig. 8

Osteitis fibrosa of the femur, seven weeks after operation.

Fig. 9-A

Fig. 9-B

Chondrosarcoma of the sternum before operation and two years after operation.

Fig. 10-B
Bone cyst of the humerus two years after operation.

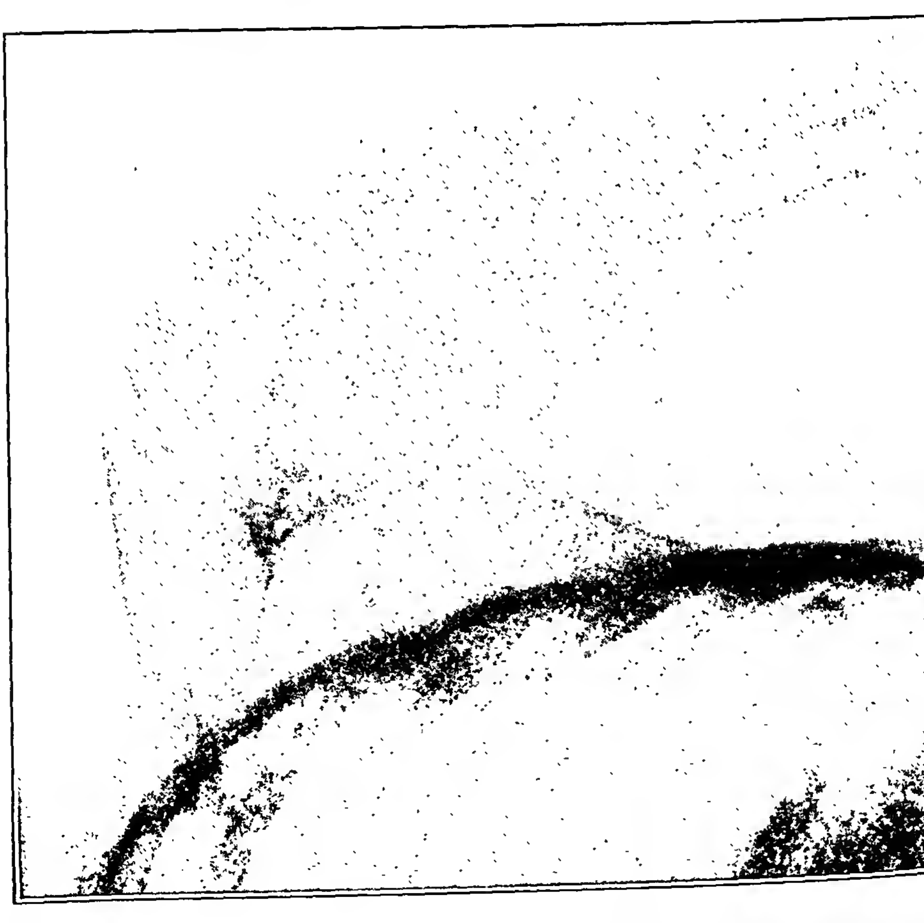

Fig. 10-A
Bone cyst of the humerus before operation.

Fig. 11-A
Osteitis fibrosa of the clavicle.

Fig. 11-B
Osteitis fibrosa of the clavicle six months after operation.

Figures 7-A, 7-B, 8, 9-A, 9-B, 10-A, 10-B, 11-A, and 11-B.) After the tumor cavity has been thoroughly cleaned out and cauterized, bone chips removed by the second operator are packed tightly into the cavity to fill it completely. This method, as Meyerding also found, "aids in filling the defect and stimulates the formation of bone". It can be carried out quickly and easily with little surgical trauma to the leg furnishing the grafts.

SUMMARY

1. Chip grafts have a wide range of usefulness in orthopaedic surgery.

2. The dangers of surgical shock and fat embolism in spinal fusions are diminished by the chip-graft method.

3. Handy chip grafts are easily obtained in large quantities without special instruments.

4. Chip grafts hasten and ensure bony union in many orthopaedic operations.

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STUDIES IN BONE FORMATION: THE EFFECT OF THE LOCAL PRESENCE OF CALCIUM SALTS ON OSTEOGENESIS

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One of the unsolved problems of ossification is the origin of the calcium which is deposited in organic bone matrix to form bone. Numerous investigators of the biochemical aspects of bone formation have failed to agree on the source of this calcium. The object of this paper is to report the results of efforts to investigate bone formation in the presence of various calcium salts.

INTRODUCTION

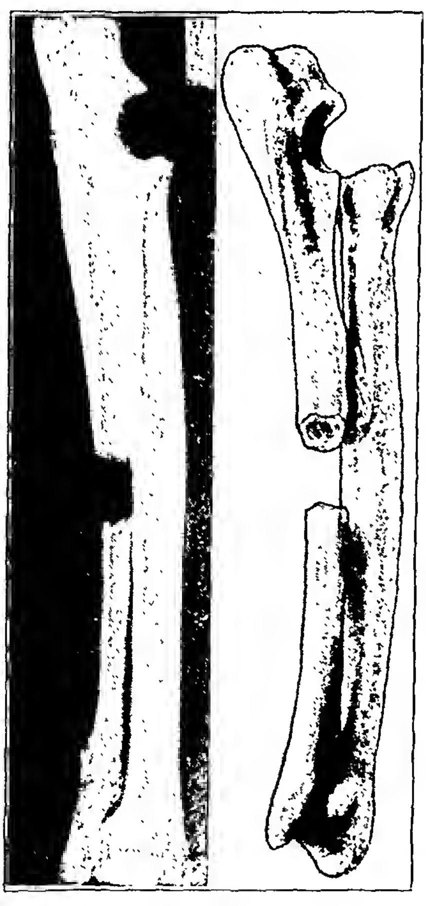
One of the first investigations of the nature of bone was made by Clopton Havers, of London, in 1691. This contribution immortalized his name and in it he first described the small canals, now spoken of as haversian canals. He did not accept the work of Harvey on the circulation of the blood, however, and failed to recognize that small blood vessels traverse these passages. In the eighteenth century John Hunter showed that bone substance is not the static resistant structure it appears to be, but that it exists in a state of constant deposition and resorption and that this activity is the important element in bone repair. This work was confirmed in 1847 by Flourens of France. Later in the nineteenth century biochemists proved by chemical experimentation that the two processes of calcium resorption and deposition are coexistent as the two elements of a reversible equation in which the inorganic calcium carbonates and phosphates represent one variable and the complicated organic salts the other. H. G. Wells, in 1911, wrote that the calcium salts exert a specific influence on the connective-tissue cells which cause them to assume active growth and to undergo a metaplasia not only into osteoblasts and bone corpuscles but apparently even into marrow cells with hematogenic function. Wells states: "In the blood we have present the anomalous condition of calcium in solution in a fluid containing carbonates, phosphates and sulphates, any one of which would throw it down in the test-tube. . . . Yet in the blood stream calcium remains in a soluble form. . . . Therefore, finding no clue [to account for the calcium deposition] on the chemical side, we naturally turn to the physical aspects." He further states that taking all the evidence as it stands we find ourselves best satisfied with that which indicates that calcification begins as a simple physical adsorption by hyaline substances which have a more or less specific adsorption affinity for calcium.

The validity of Wells's original hypothesis has been proved by Leriche and others. This hypothesis holds that whatever the chemical nature

of the reaction, given a proper physical environment within the organism such as an area of tissue necrosis or localized formation of hyaline substance, calcification is likely to occur, and, following calcification under such circumstances, ossific metaplasia may be expected. This is true of the normal as well as of the pathological development of bone.

Robison, working in England in 1923, succeeded in isolating an enzyme which by hydrolysis causes the deposition of calcium from organic salts such as the calcium phosphoric esters of hexose which are present in the blood stream. He believed that this enzyme is secreted in the region of the osteoblasts and the hypertrophic cartilage cells. The enzyme was called "phosphatase" because it has become recognized that in the process of calcification the phosphorus radicals are the hydrolyzable elements.

Another school of thought in bone investigation, opposed to the humoral or chemical hypothesis, was composed of a group of men who believed that bone is formed by the direct action of specific cells according to a cellular or vital action. John Goodsir, Professor of Surgery at the University of Edinburgh at the beginning of the nineteenth century, believed that a specific cell, such as the osteoblast, is an actual builder of bone and utilizes the material of its environment in the building process. William MacEwen later in the nineteenth century experimented along these lines and in 1912 published a classical monograph on bone formation. Like Goodsir, MacEwen was an advocate of the cellular theory, believing that osteogenesis is the function of osteoblasts alone and that resorption is effected by another group of tissue cells, the osteoclasts.



A B

FIG. 1

Typical defect in ulna. (This dog died one day after operation.)
A: Roentgenogram.
B: Drawing of specimen.

During this same period, Ollier in France carried on a rather extensive series of experiments in bone formation. He believed that the periosteum is the mother tissue of bone and that the cambium layer of this membrane is by far the most important factor in the production of bone cells. He also believed that the bone marrow possesses an osteogenic power and that cortical bone itself is the least important factor in bone growth. MacEwen, after extended experimentation, was apparently of the same opinion.

The work of Leriche and Policard on the physiology of bone, published in recent

years, has already become a classic. These authors are champions of the humoral or chemical theory and postulate "a local calcific surcharge as the determinant of osteogenesis in a suitable fibrous medium". They believe that with the rarefaction of fracture fragments calcium salts are liberated in the vicinity, leading to a local excess of calcium, and that this calcium is an important factor in the union of fractures. Murray, after exhaustive experimentation, believes that calcium phosphate and carbonate in the proportion in which they occur in the bone can be used as a local calcium depot in the process of bone formation and that they form a stimulant to osteogenesis. Key has been unable to confirm the work of Murray. From his experiments upon dogs he concludes:

A B C D

FIG. 2

Experimental (*A* and *B*) and control (*C* and *D*) defects in same dog.
A: One day after operation. Defect filled with calcium glycerophosphate.
B: Twelve weeks later. There is slight proliferation of bone with decrease in the width of the defect.
C: One day after operation. Defect not filled with calcium glycerophosphate.
D: Twelve weeks later. There is absorption and atrophy of bone ends with increase in the length of the defect.

"Neither calcium phosphate and carbonate in the proportion in which they occur in bone, nor bone powder, made by removing the organic matter from bone, appear to stimulate osteogenesis of bone when im-

planted in a bone defect." This same opinion is held by Phemister. In the presence of these differences of opinion the problem is distinctly unsolved. The author's personal interest in this investigation has been stimulated by contact with Murray. The present investigations were carried out from 1931 to 1933 and constitute an attempt to prove or to disprove that calcium salts at the site of new bone formation stimulate osteogenesis.

EXPERIMENTS

A preliminary group of experiments on seventeen dogs were performed in an attempt to determine which salts of calcium are associated with the most rapid bone formation. With a burr, one centimeter in diameter, a hole was bored from the flat outer surface of the upper portion of the tibia into its medullary cavity. The hole was then filled with calcium salts. The controls were of two kinds: (1) the holes were filled with bone chips, and (2) the holes were left empty. Three types or combinations of calcium salts were used:

1. Calcium triple phosphate, three parts; calcium carbonate, one part,—the same proportion as found in the blood.
2. Calcium glycerophosphate, which has been shown to be the calcium salt upon which the enzyme phosphatase has the most specific action in bone formation.
3. Bone ash, which contains, in addition to calcium phosphate salts, magnesium and iron as chlorides and sulphates whose influence on bone formation is unknown.

Of the seventeen dogs, twelve were suitable for providing reliable data. The defects were examined in from three to eleven weeks after operation; all of them contained solid bone. More bone was found in the control defects than in those filled with calcium salts. Defects containing calcium glycerophosphate showed a larger amount of bone formation than those in which the other salts of calcium had been used.

TABLE I

CALCIUM SALTS EXPERIMENTS—FIRST SERIES: THE ULNA

Type	No. of Experiments	Average Volume of Bone Formation (*Per Cent.*)	Group Average (*Per Cent.*)
Calcium glycerophosphate	12	43.3	
Calcium triple phosphate (3 parts) Calcium carbonate (1 part)	6	36.6	43.2
Bone ash	4	40.0	
Calcium gluconate	3	60.0	
Control	6	20.0	20.0
Total	31		

TABLE II

Calcium Salts Experiments—Second Series: The Ulna

Type	No. of Experiments *	Average Volume of Bone Formation (*Per Cent.*)	Average Percentage of Defect Containing New Bone Formation
Calcium glycerophosphate.	7	40.0	49.1
Control..................	7	20.0	40.7
Total................	14		

* The same animals (7) were used for both experimental and control operations.

Following these preliminary experiments, a series of experiments on thirty-nine dogs were started. Thirty-one of these animals proved satisfactory for furnishing experimental data. A defect about one and five-tenths centimeters in length was created in the middle third of the ulna and filled with the calcium salts. The periosteum was removed as carefully and as completely as possible. The bone was taken out by the use of Gigli saws and bone cutters. Great care was used not to injure the adjacent portion of the radius. This procedure was carried out in twenty-five dogs, while in a control group of six animals the same technique was

A B C D E

Fig. 3

Roentgenograms and specimen after calcium glycerophosphate had been placed in the defect in the ulna. Roentgenograms (*A*) three weeks, (*B*) seven weeks, (*C*) eleven weeks, and (*D*) six months after operation. Specimen (*E*) six months after operation. Note the progressive increase in the amount of bone formation in the defect. The specimen appears to show solid union, but the last roentgenogram shows that the union is still incomplete

used without the addition of the calcium salts. None of the control operations were performed in the same animal as the experimental operations. The dogs were all adult animals but varied from distinctly small to large size. After the first one or two experiments no attempt was made to immobilize the leg in plaster. Calcium gluconate, which is so often employed clinically as a source of calcium, was used in addition to the calcium salts previously mentioned. The experiments were allowed to run for from three weeks to ten months. Roentgenograms were taken at different intervals, but unfortunately not at the same time interval in each case. The amount of bone formation has been estimated at the time of the last roentgenogram as well as at the time of the post-mortem examination. This has been expressed in terms of the estimated percentage as follows: A slight amount of bone formation has been rated 20 per cent.; a small amount, 40 per cent.; a moderate amount, 60 per cent.; a large amount, 80 per cent.; and solid union across the gap, 100 per cent. It is realized that this is entirely a personal estimate and that it is not exact. Table I shows the averages of the total number of experiments with each calcium salt and the controls.

A B C

FIG. 4

Roentgenograms and specimen after calcium glycerophosphate had been placed in the defect in the ulna. Roentgenograms (*A*) six weeks, and (*B*) one year after operation. Specimen (*C*) one year after operation. The defect has been completely filled with new bone.

The largest group of experiments were done with calcium glycerophosphate, because of its being most subject to the specific action of phosphatase and because from the preliminary work it was found that bone formation was most abundant with this salt. In this series there is no greater bone formation with calcium glycerophosphate, however, than with the other salts, but the number of experiments with the other salts is small. The average volume of bone formation when calcium salts

are present is 43.2 per cent., as compared with 20 per cent. for the controls; this represents a ratio greater than 2 to 1.

From the experience gained with the first series, it was believed that there were a great many sources of error which might influence the results. The following points were taken into consideration in a second series: The dogs were more nearly the same size; the location of the ulnar defect was more uniform; and exactly the same length of bone was removed from each animal (this was done by using a double motor saw with the blades set apart at a distance of one and five-tenths centimeters). Great care was taken not to cause excessive bleeding. The operative field was thoroughly washed out with saline solution after the removal of the bone segment and its periosteum. All roentgenograms were taken at exactly the same distance with the same exposure, in order to secure comparable records of bone density. Experimental and control operations were done upon the same animal, the right leg being used for the control and the left leg for the experiment. Roentgenograms were made at intervals of approximately one day, one week, two weeks, four weeks, eight weeks, and twelve weeks. In each case the last roentgenogram was made twelve weeks after operation. Calcium glycerophosphate alone was employed in this series. Thirteen animals were used. Six of these either became infected or died, seven satisfactory experimental animals remaining. The aver-

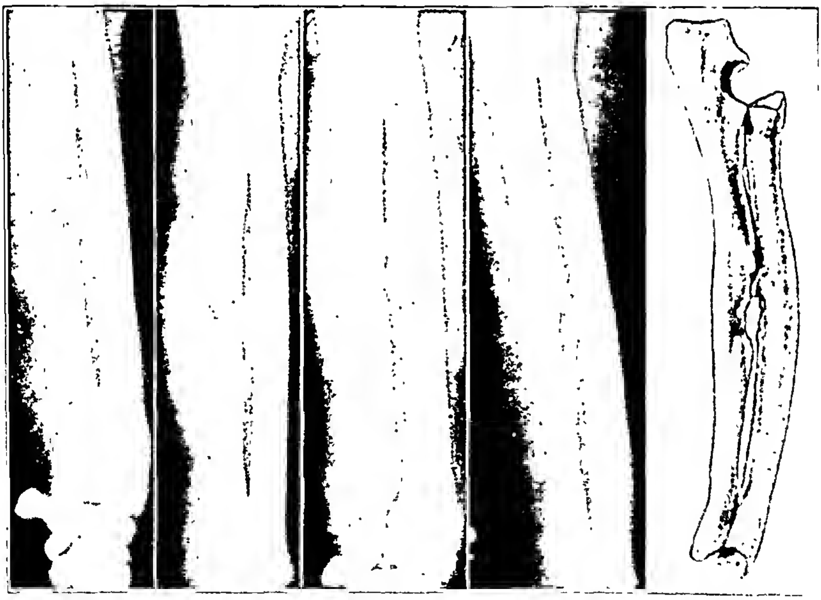


Fig. 5

Roentgenograms and specimen after calcium triple phosphate (3 parts) and calcium carbonate (1 part) had been placed in the defect in the ulna. Roentgenograms (*A*) one week, (*B*) five weeks, (*C*) ten weeks, and (*D*) six months after operation. Specimen (*E*) eight months after operation. Note that the gradual increase of new bone fills the defect completely in six months.

TABLE III

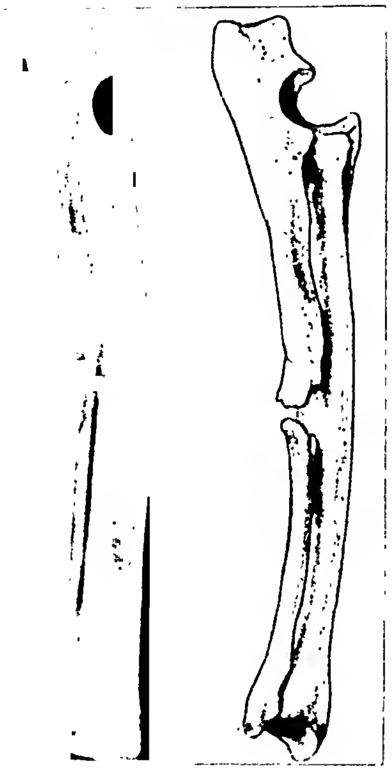
CALCIUM SALTS EXPERIMENTS—COMBINED FIRST AND SECOND SERIES: THE ULNA

Type	No. of Experiments	Average Volume of Bone Formation (*Per Cent.*)
Calcium salts........................	32	42.5
Control..............................	13	20.0
Total..........................	45	

age volume of bone formation was 40 per cent. for the experimental bones and 20 per cent. for the controls. (See Table II.) The roentgenograms were also studied to determine the percentage of the defect which contained new bone formation regardless of the bone volume. It was found that in the experimental bones 49.1 per cent. of the length of the defect contained new bone, while in the controls 40.7 per cent. of the length showed new bone formation.

Table III shows the combined first and second series. There were thirty-two experimental and thirteen control operations, or a total of forty-five experiments. The average volume of bone formation was 42.5 per cent. for the experimental and 20 per cent. for the control operations, a ratio of 2.1 to 1. The results of these experiments certainly suggest that in bone formation in the ulna the local presence of calcium salts stimulates the process. This does not prove, however, that they supply the calcium actually used in the calcification of the organic bone matrix.

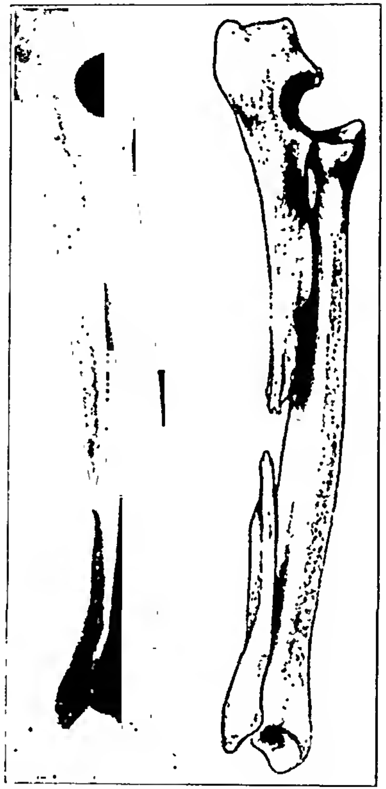
A third series of experiments were performed in an attempt to determine whether the local use of calcium glycerophosphate in spine-fusion operations is of value. The surgical procedure which was used in all of the experimental operations on the spine was a modification of the Hibbs fusion technique. It consisted of removing the spinous processes, chipping up the posterior surface of the laminal arches and the articular facets, and replacing the chips along the raw, bleeding surface of the bones. In all of these experiments from three to four vertebrae were operated upon. Twenty-five dogs were used in this series, seventeen of which were satisfactory for furnishing data. All dogs were sacrificed after twelve weeks. The eight unsatisfactory animals either became infected or died too early to be of value. In seven dogs calcium glycerophosphate was poured into the wound or mixed with the chips. Five dogs were used as controls; in these the chips were employed without the addition of calcium glycerophosphate. In two dogs all of the chips, including the spinous processes, were removed and not replaced; this raw bony surface was then covered with calcium glycerophosphate. In three dogs the same procedure was carried out without the addition of calcium glycerophosphate. Adequate tabulation of the results is difficult. The greatest amount of bone formation and the strongest fusion occurred in the control



A B

FIG. 6

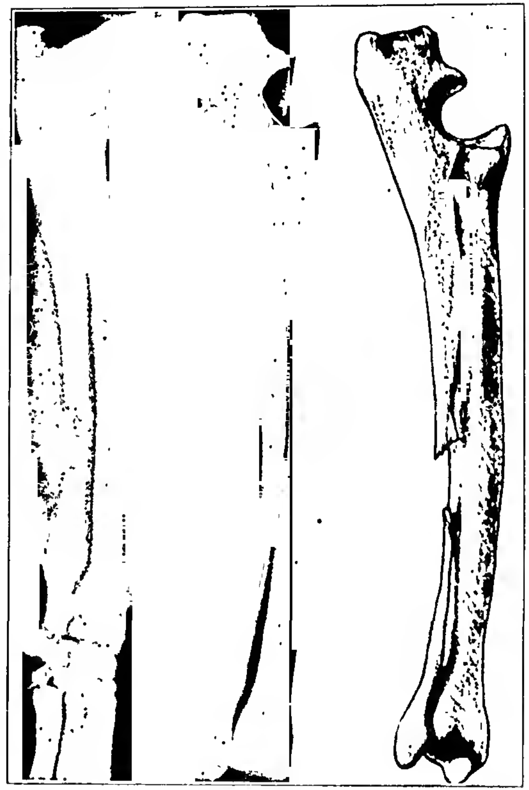
Roentgenogram (*A*) and specimen (*B*) nine and one-half months after the defect in the ulna had been filled with calcium gluconate. Note that approximately three-fourths of the defect is filled with new bone.



A B

FIG. 7

Roentgenogram (*A*) and specimen (*B*) thirteen and one-half months after the defect in the ulna had been filled with bone ash. Note that the ends of the fragments are pointed and that the defect is only slightly shortened by new bone.



A B C

FIG. 8

Roentgenograms (*A* and *B*) and specimen (*C*) of control experiment. No bone salts were placed in the defect in the ulna.

A: One day after operation.

B and *C:* Sixteen months after operation.

Note the absorption and pointing of the ends of the fragments and the very slight shortening of the defect.

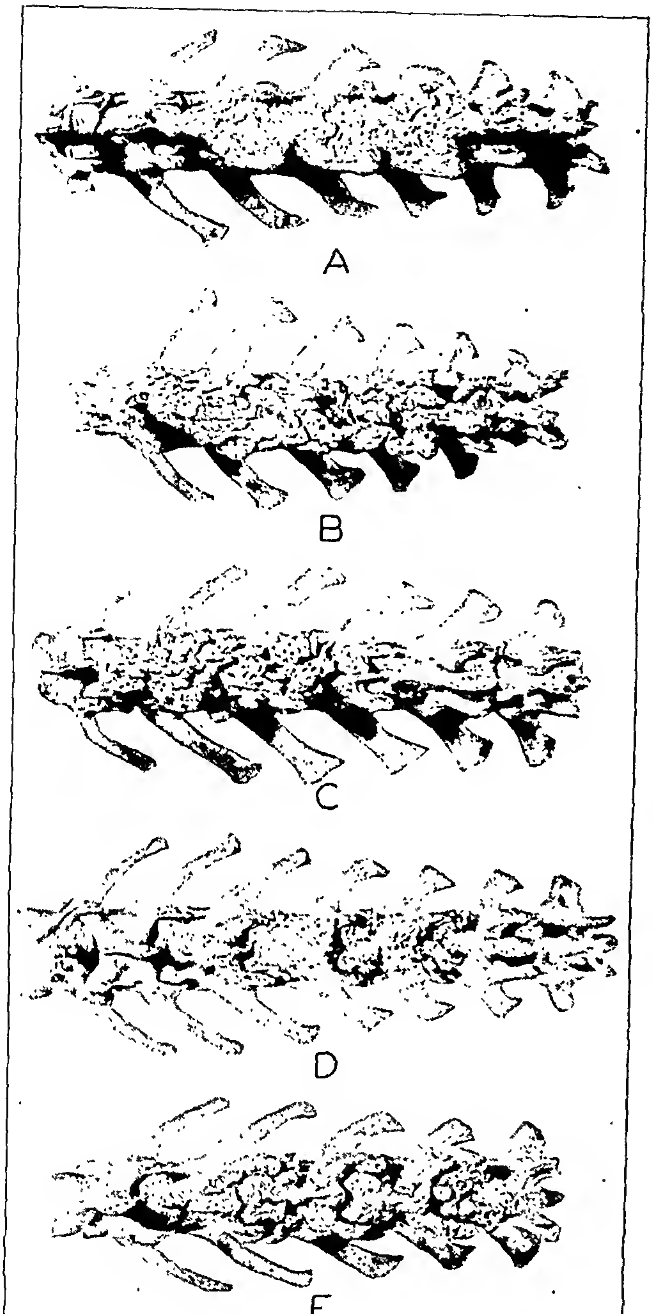


FIG. 9

FIG. 9

Photographs of specimens from spine experiments in osteogenesis. The dogs were sacrificed after twelve weeks.

A: Hibbs fusion—chips not removed, but covered with calcium glycerophosphate. Note the smooth new bone formation; however, there are two places in which the bridging of bone is not complete.

B: Hibbs fusion—control experiment, chips not removed. The amount of new bone formation is greater and the bony union is more solid than in *A*.

C: Hibbs fusion—control experiment, chips removed and replaced. The bony union is firmer than in *A* or *B*.

D: Removal of spinous processes and laminal surfaces; bleeding bone covered with calcium glycerophosphate. Note the almost complete absence of new bone formation.

E: Removal of spinous processes and laminal surfaces. Control experiment. Note the large amount of new bone formation about the articular margins as contrasted with the lack of new bone in *D*.

group of spines fused according to the usual Hibbs technique. (See Table IV.) In three of these five animals the chips were taken out and then replaced along the bleeding surface in regular order; this group showed more bone formation than those in which some of the chips were left partially attached. There was a moderate amount of bone formation in those animals in which the Hibbs fusion had been done with the addition of calcium glycerophosphate, but the spines were not so solidly fused as those in the control animals. In the second group, the most surprising finding was the amount of new bone formed in the spines of control animals from which all of the chips had been removed and to which no calcium salts had been added. There was actually piling up of bone about and around the articular facets and the adjacent laminal arches. There was little bone formation in cases in which calcium glycerophosphate was added after all of the chips had been removed. The five cases

TABLE IV

CALCIUM SALTS EXPERIMENTS—THIRD SERIES: THE SPINE

Type	No. of Experiments	Amount of Bone Formation
1. Hibbs fusion with calcium glycerophosphate......	7	Moderate
2. Control—same as No. 1 but without calcium glycerophosphate..............................	5	Large
3. Hibbs fusion without replacement of bone chips and with addition of calcium glycerophosphate..	2	Slight
4. Control—same as No. 3 but without addition of calcium glycerophosphate....................	3	Moderate
Total...................................	17	

in this second series of spines are too few, however, to allow definite conclusions to be formulated. From operating upon these spines and examining the specimens, one gains the impression that calcium salts do not here stimulate osteogenesis as they apparently did in the case of the ulna. The discrepancy is perhaps best explained upon a circulatory basis. The local circulation about the spine is always more abundant than that in the foreleg. It seems likely that in the case of the spine the calcium salts are rapidly absorbed and taken away from the site of bone formation and that this does not occur in the foreleg where the circulation is less plentiful.

CONCLUSIONS

1. In defects in the ulna of the dog, calcium salts appear to stimulate bone formation.

2. In operations upon the spine, calcium salts in the form of calcium glycerophosphate do not stimulate bone formation and appear rather to exert an inhibiting influence.

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ELECTROLYTIC DESTRUCTION OF BONE CAUSED BY METAL FIXATION DEVICES *

BY WALTER G. STUCK, M.D., SAN ANTONIO, TEXAS

In the treatment of fresh fractures it is often impossible to retain fragments in the reduced position without some sort of metal wire, screw, nail, plate, or band. Moreover, in the reconstructive surgery of old fractures, these devices are needed at times to secure bones in the desired position. Even when bone grafts are used for this purpose, some appliances must be utilized to anchor them. Thus, in certain fractures of the shoulder, or of the shaft of the humerus, or of the condyles of the tibia and femur, open operations are necessary to restore the fragments to their normal position, and metal appliances are usually required to hold the fragments in the desired relation to each other.

It has been discovered clinically that most metals used in bone surgery cause erosion of the bone, as evidenced by roentgenograms, or soft-tissue reactions which produce tenderness and pain. Attempts have been made by many orthopaedic surgeons to avoid these unfavorable complications by using kangaroo tendon, beef bone, or strips of fascia lata instead of the usual metal appliances. Others have developed metal fixation devices which can be removed, after they have served their purpose, without a subsequent operation. Such substitutes have served fairly well, although there are still certain types of fractures where nothing can replace the use of metal fixation.

Until recently the mechanism of

FIG. 1

C. B., male, aged thirty-four years. Old fracture of the upper end of the left tibia three months before admission, with non-union. On September 13, 1935, the fracture was explored. The fibrous tissue was removed, and a Parham band was applied. The roentgenogram, seven months later, shows erosion of the bone about the band and overgrowth of adjacent cortical bone. Considerable local tenderness and irritation were noted, but solid union of the fracture resulted.

* Read at the Annual Meeting of the Texas Railway Surgeons Association, Fort Worth, Texas, May 10, 1937.

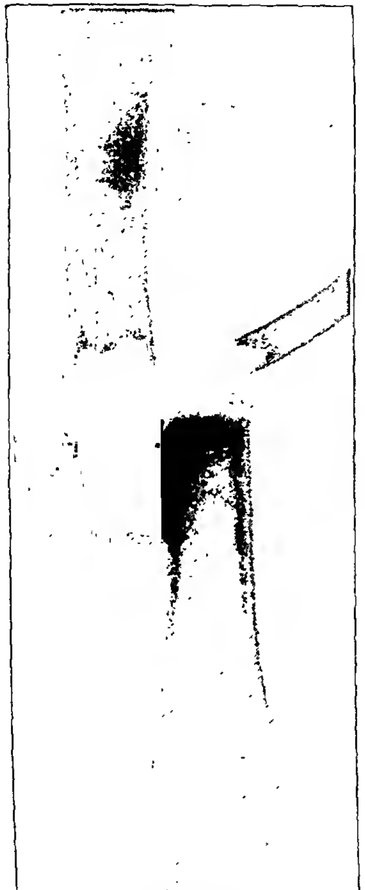

Fig. 2-A

Fig. 2-B

Fig. 2-A: Y. E., male, aged ten years. Roentgenogram taken on November 5, 1935. The patient had sustained a fracture of the femur three weeks before, with marked over-riding of the fragments.

Fig. 2-B: Roentgenogram after reduction, with fragments

Fig. 2-B (*Cont'd*):

secured by two Parham bands and plate. In spite of perfect reduction, there was marked delay in the healing, which required removal of the bands and plate and fixation in a plaster cast for several months.

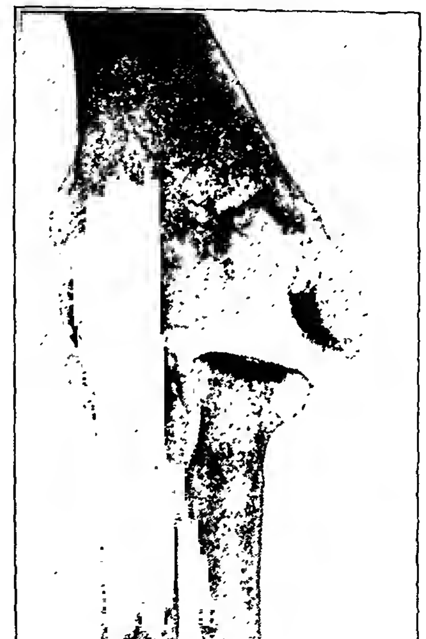

Fig. 3-A

C. E. P., male, aged forty-two years. On April 19, 1936, the patient sustained a fracture of the external condyle of the left humerus, with rotation of the fragment.

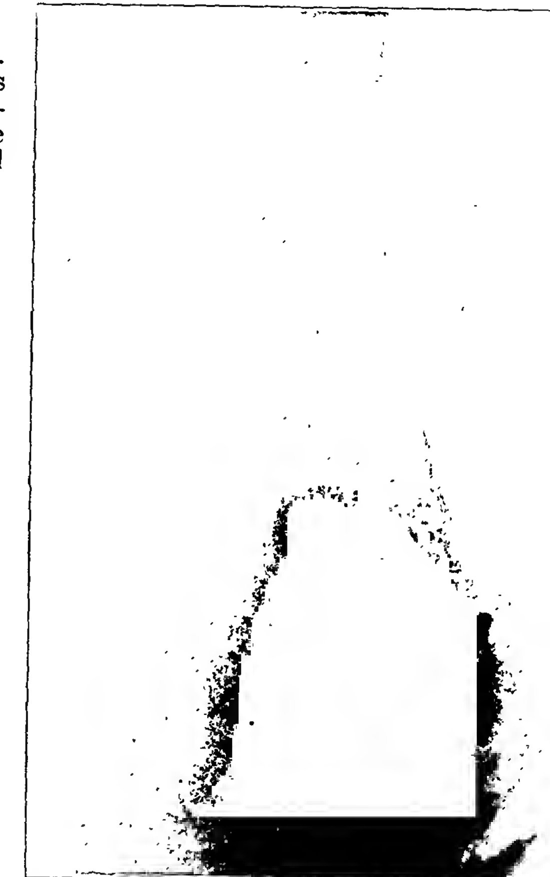

Fig. 3-B

Postoperative roentgenogram after reduction of the fracture and fixation with two copper-plated square steel nails. Solid bony union resulted, although much local irritation and tenderness were present, which necessitated removal of the nails.

FIG. 4-A

M. G., male, aged thirty-seven years. Fracture of the external condyle of the right tibia, with a small fragment of bone in the fracture line. The fracture was explored, the scrap of bone was removed, and the fragments were reduced.

FIG. 4-B

After reduction, showing perfect reposition of the fragments anchored by the author's method of removable crossed Kirschner wires. The wires were removed at the end of four weeks. Good function resulted.

the destruction of bone by metals has not been adequately understood. Zierold, Jones and Liebermann, Cretin and Pouyanne, Ménégaux and Odiette, to mention the more important investigators, have studied in detail the reaction of bone and soft tissues to various metals in an effort to discover the least toxic and more suitable materials. There is no uniformity in their recommendations of the best metal to use, and, in fact, their conclusions are more often contradictory.

In 1936, Venable, Stuck, and Beach,[1] at the Southern Surgical Association, reported the results of exhaustive experiments on the reaction of bone to different metals, which seemed to offer a clear solution to this puzzle. Chemical examinations of the bones and soft tissues revealed definite proof of electrolytic activity about screws of the metals commonly used in bone.

On the basis of previous animal experiments and of the clinical observations herein presented, it has been determined that, to avoid electrolytic destruction of bone when metals are used, the following facts must be recognized:

1. Pure metals of low toxicity (for instance, silver wire) are suitable if tensile strength is not required. Nevertheless, different pure metals should not be used in the same bone, since they will induce electrolytic reaction.

2. Alloys which contain iron are undesirable, since the local electrolysis (hysteresis) releases metallic ions in the blood stream and often produces toxic symptoms. Local reactions, furthermore, erode the bone adjacent to the alloy and annul its effectiveness.

3. Plated metal appliances are destructive to bone, since the plating

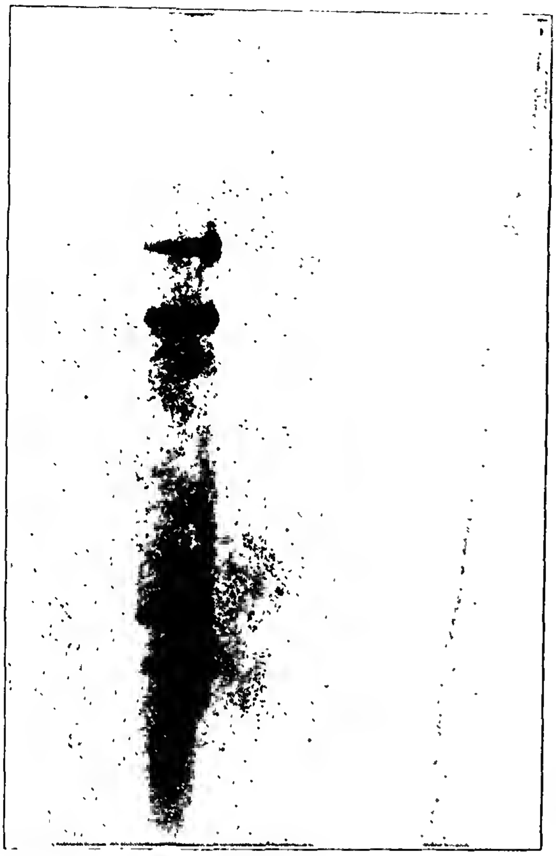

Fig. 5-A

Fig. 5-B

Fig. 5-A: C. B., male, aged twenty-two years. Fracture of the junction of the middle and upper thirds of the left femur, with malunion. On September 10, 1936, the fracture was explored. The fragments were replaced in their normal position. A beef-bone plate was applied and anchored with four vitalium screws. (This patient was operated upon before vitalium plates were available.)

Fig. 5-B: Roentgenogram of femur seven months after the operation, showing strong bony union. There is absolutely no bone absorption or reaction about the vitalium screws.

becomes cracked and allows dissimilar metals to be side by side in the electrolyte (body fluids) as is the case with a storage battery.

4. Alloys in which the constituent metals are adjacent in the E. M. F. (electromotive) series and which, therefore, possess slight differences of potential do not cause electrolysis and are not injurious to bone. Such an alloy of cobalt, chromium, and nickel (vitalium) has been cast into plates, screws, and nails which have been found to be completely noninjurious to bone. Roentgenograms taken months after the vitalium screws have been inserted reveal no necrosis of bone about the screws, as they do about all other commonly used metals, and there is no local pain or tenderness over the screws. Animal experiments likewise have shown that vitalium screws are tight in the bone months after their insertion, whereas other screws become loosened and ineffective. Finally, pathological examinations have revealed a minimum of reaction in the bone and soft tissues near these vitalium plates and screws.

1. Venable, C. S., Stuck, W. G., and Beach, Asa: The Effects on Bone of the Presence of Metals; Based upon Electrolysis. An Experimental Study. Ann. Surg., CV, 917, 1937.

SPINAL-CORD COMPRESSION ASSOCIATED WITH SCOLIOSIS

Report of a Case

BY CLARENCE H. HEYMAN, M.D., F.A.C.S., CLEVELAND, OHIO

From the Gates Hospital for Crippled Children, Elyria, Ohio

The fact that up to the present time only twenty-eight cases of paraplegia occurring as a complication of scoliosis have been reported indicates that this condition is rare. In a study of museum specimens showing markedly severe scoliosis it has been the common observation that the size of the spinal canal is adequate for the spinal cord without bone encroachment upon it. Paraplegia complicating scoliosis is new in the experience of the writer, and also has been unheard of by the many orthopaedic surgeons with whom he has conferred. Therefore, the author feels that the report of such a case is of value, particularly since there have been opportunities for observation which have not been heretofore recorded. The observations of others will be presented first in order that the reader may be informed on the subject beforehand and appreciate the unusual features of this case.

While paraplegia occurs as a complication of Pott's disease, it is usually attributed to the pressure of an abscess or the growth of tuberculous granulation causing pressure upon the cord. The writer, however, recalls having done laminectomies in two cases of Pott's disease, in which there was complete motor and sensory paralysis with loss of sphincteric control where no pressure of soft parts (abscess, granulations, or extradural mass of fat at the site of the angulation) was found. The dura and cord were found to be tightly stretched over an acutely angular bone deformity. In both of these cases the paralysis occurred during adolescence, and the site of the disease was in the upper dorsal region. It is noteworthy that both patients had had Hibbs fusion operations done many years before and, with the exception of the paraplegia, there was no indication of activity of the disease. One of these patients made a good recovery at the end of six months; the other one did not improve.

SURVEY OF THE LITERATURE

The reader will not be burdened by a detailed review of all case reports. For those who wish to consult the original articles, a bibliography is appended. Particular reference should be made, however, to the article by Mauclaire, who in 1913 was the first to record paraplegia occurring in scoliosis, and to the important work of Jaroschy, whose detailed studies are referred to in all subsequent reports. The publication by Valentin and Putschar is of particular interest because they give a complete report of the pathological findings of the spinal column and cord in the case of a nineteen-year-old boy who died with paraplegia associated with scoliosis.

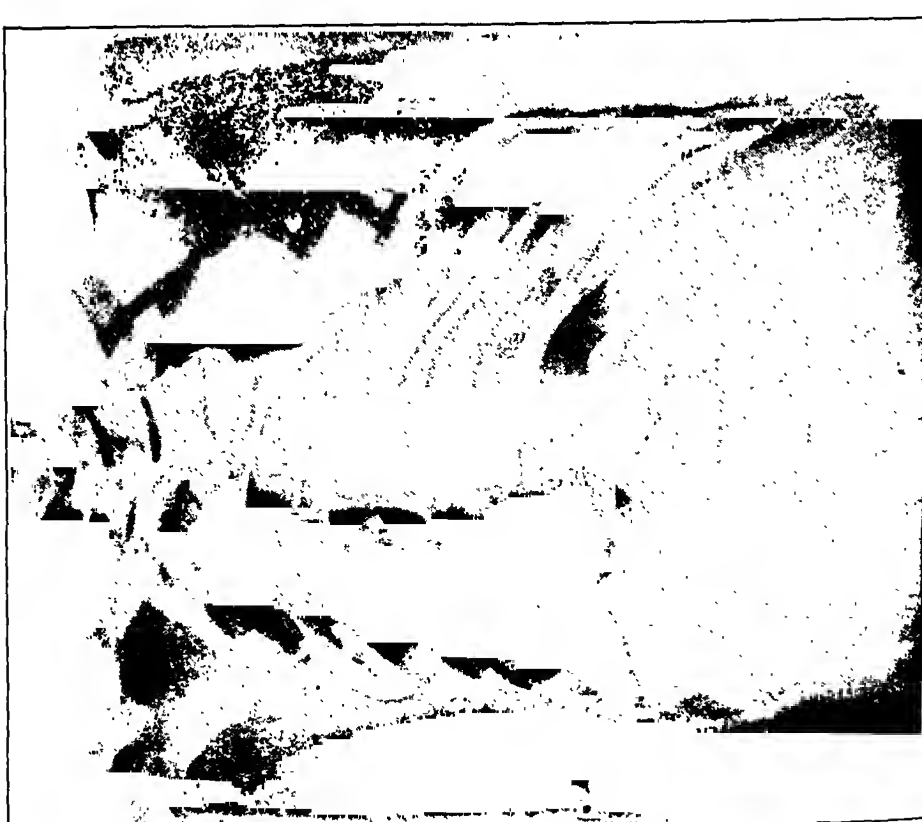

FIG. 1

E. B., female, ten years of age. Roentgenogram on September 5, 1930, showing congenital scoliosis with wedging of vertebrae and fused ribs.

FIG. 2

Roentgenogram on February 5, 1932, showing progression of the deformity.

Fig. 3

Roentgenogram on August 4, 1931, at the time of the appearance of paraplegia. Note the bayonet shape of the deformity.

Fig. 4

Roentgenogram on June 16, 1936, two years after laminectomy and after attempted spine fusion. The patient is now seventeen years old and remains completely well.

ANALYSIS OF CASES PREVIOUSLY REPORTED

A review of the twenty-eight cases of paraplegia associated with scoliosis previously reported shows that the majority of the cases occurred during adolescence and were associated with either a long-standing congenital scoliosis (60 per cent.) or a severe paralytic scoliosis (40 per cent.). The apex of the curve was at or above the middorsal region. The level of the paralysis almost always corresponded to the highest point of the curve. In all cases the paralysis developed rapidly in intensity, but complete cessation of function with paralysis of the sphincters was present in only 33 per cent. of the cases reported. In eight of the recorded cases there was no record of treatment or of outcome. Of twenty-three cases where the sex was recorded, seventeen, or 74 per cent., were males. Root pain was present in only one case.

Laminectomy was done in ten cases, followed by a satisfactory response to treatment in six, partial recovery in three, and death in one case. Conservative treatment in ten cases resulted in a satisfactory response in only two, improvement in six, and no improvement in two. The dura was opened in all cases operated on except one, and it was the common experience that it was impossible to close the dura because of herniation of the cord through the opening. In most cases it was reported that the dura was under tension or tightly stretched over an angular bony prominence, but no mention is made of the removal of any spicule of bone or bony prominence. An extradural mass of fat was recorded in eight cases, but was not considered a factor in the causation of the paraplegia. Spinal puncture gives evidence of a subarachnoid blockage, and the injection of lipiodol visualizes the level of obstruction.

CASE REPORT

During the time that the patient in the following case was under treatment, the writer was unfamiliar with any previous occurrence of paraplegia associated with scoliosis.

E. B., a girl, ten years old, was first examined at the Gates Hospital for Crippled Children on September 5, 1930, because her parents had recently noticed that one shoulder was higher than the other. There was no complaint. Examination showed only a slight and abrupt lateral curvature at the upper dorsal region with the left scapula one inch higher than the right. The posture was poor. There was no asymmetry of the chest. Roentgenographic examination (Fig. 1) showed a congenital scoliosis at the upper dorsal region with wedge-shaped vertebrae and fused ribs. Postural treatment only was prescribed. The parents were told that this deformity must be watched, and were advised to bring her back for periodic observations and roentgenograms.

The patient was examined three months later and again at the end of six months. There was great improvement in posture, but the left scapula remained a little high as before. There appeared to be no increase in the scoliosis. At the end of eleven months, in August 1931, it was observed that the lower right ribs posteriorly were slightly prominent. Her posture was excellent. On February 5, 1932, seventeen months after the original examination, the prominence of the ribs on the right side was more marked. A roentgenogram (Fig. 2) on that date showed a moderate increase in the angulation. In view of this increase in deformity, shown only by the roentgenogram, a spine-fusion

operation was under consideration. However, this was not urged in view of there being no gross deformity of any consequence.

On June 16, 1933, it was noted that the patient had been growing quite rapidly. In June 1934, almost four years following the original examination, there was no increase in the gross deformity, the posture was good, there was no list, the shoulders were practically level, and the slight prominence of the lower ribs on the right side had not increased. There was no complaint. Postural exercises had long since been discontinued, and the patient was told to return for observation at the end of six months.

On July 25, 1934, she returned with the history of having had an acute attack of jaundice six weeks previously, and during the past month she had been having increasing difficulty in the use of her right leg. She had had no pain, no headache, and no disturbance in the control of the bladder or the rectum. Examination revealed a definite ataxia of the lower extremities and a positive Romberg sign. The ankle and knee jerks were increased and there was a bilateral Babinski reflex. There was no disturbance in sensation. The pupils were normal and there was no nystagmus. The upper extremities showed nothing abnormal. Examination of the back showed no increase in the gross deformity, and the posture was excellent.

On August 22, 1934, after one month in bed, both lower extremities had become completely paralyzed, and there was practically no control of the bladder or rectum. There was a complete loss of sensation to touch, and pain was present over both lower extremities and extending to the level of the fourth thoracic segment. The patient lay with the hips and knees in complete extension, and there were no mass reflexes. The tonicity of the muscles of the lower extremities was increased with very active knee and ankle jerks. The Babinski reflex was present on both sides. Roentgenographic examination (Fig. 3), at the time of the appearance of paraplegia, showed a wedge-shaped formation of the third and fourth thoracic vertebrae with the body of the fourth displaced markedly toward the left.

Since symptoms had rapidly progressed in spite of complete bed rest, laminectomy was advised. It was evident that there was a compression of the cord, and no spinal-fluid studies were made. At operation, on September 5, 1934, there was found a marked irregularity of formation of the spinous processes and arches of the third and fourth thoracic vertebrae. These arches were removed by means of rongeurs. The dura was exposed and was found to be pulsating normally. A ureteral catheter could easily be passed upward between the dura and the arches, meeting with no obstruction, but a definite obstruction was encountered below under the malformed arch of the fourth thoracic vêrtebra. Accordingly, this arch was removed. There was found at this level a definite bony constriction of the canal below which there was no pulsation of the dura. The lamina of the fifth thoracic vertebra was also removed, and below this the catheter could be passed easily with no obstruction. The cord appeared to be passing over an acutely angular bone deformity anteriorly. This surface was explored by dividing one root between ligatures, and the cord was then rotated. There was found a nodule of bone, apparently causing pressure on the anterior surface of the cord. This was removed. The nerve roots were not taut, and the dura did not appear to be under tension. Therefore, it did not seem that anything would be gained by opening the dura, especially since a definite bony constriction had been found and removed. The wound was closed tightly in layers, and the patient was returned to bed in good condition on a Bradford frame.

Postoperative recovery was rapid and complete. Three weeks after operation the patient regained normal control of the bladder and rectum, and there was a slight return of power in the use of the legs. Nine weeks after operation she had good active power in the use of both legs, and there was a return to normal sensation. The knee and ankle jerks were no longer definitely active, and the Babinski reflexes had practically disappeared.

The subsequent course has been uneventful, excepting for a subsequent operation on December 5, 1934, three months after laminectomy, when a bone graft from the tibia

was used to bridge the defect of the laminae. It was thought advisable to attempt stabilization, which would possibly prevent further displacement and recurrence of compression. Aside from a temporary return to spasticity, appearing three days after this secondary operation and lasting only for one week, recovery has remained complete.

It is now more than two years since operation and the patient remains completely well at seventeen years of age. The last roentgenogram (Fig. 4), taken on June 16, 1936, shows a remarkable offset of the bodies which has progressed since the attempted fusion operation.

DISCUSSION

The facts that this patient had been under observation for four years previous to the onset of the paraplegia, that the progression of the deformity was observed by a series of roentgenograms, and that the gross deformity was only slight are of particular interest. At operation the dura was not opened, and a mass of bone causing compression was found and removed, resulting in a rapid and complete recovery.

In regard to treatment of cord compression associated with scoliosis, it is difficult to establish any uniform method to be followed in every case. It would seem that conservative treatment on a frame or plaster shell should be tried first, in view of the reports of recovery following this line of therapy. However, if paralysis progresses during treatment, or if it does not shortly diminish, laminectomy is the method of choice. All writers who have operated are agreed that the dura should be opened and the cord decompressed. The decision to do this must rest on the judgment of the surgeon. If the dura is obviously stretched over a bony angle which cannot be removed, or if it is taut because of tension of nerve roots, it would seem best to incise the dura and leave it open or, possibly, to section the roots under tension to release traction on the cord. Where a projecting mass of bone is found exerting pressure, or where the arches are causing compression, it is obvious that the cause of the pressure must be removed. Exploration along the lateral and anterior surfaces of the cord must be carried out to determine the presence or absence of a projecting mass of bone or cartilage.

It would seem that degrees of spasticity less than those amounting to a paraplegia are more frequent, and at the first evidence of weakness or spasticity in the lower extremities coexisting with scoliosis the patient should be put to bed. It is also suggested that paraplegia occurring during adolescence, years after Pott's disease in early childhood has been arrested, is more likely caused by bony compression or a tightly stretched dura than a return to activity of the disease.

The occurrence of the case recorded here and of the cases reported in the literature would indicate that the patient with a congenital scoliosis should be carefully watched by roentgenograms, especially during the active-growth period of adolescence, for a progression of any vertebral displacement. It would also seem that a spine-fusion operation is indicated when this is demonstrated, even in the absence of an apparent increase in the gross deformity. This should not be undertaken, however, with the assurance that cord compression will be prevented, for, in

the light of our present knowledge concerning the anatomical abnormalities causing compression, a fusion operation will not preclude a subsequent appearance of these abnormalities. The writer is convinced that this was particularly true in two cases of cord compression which occurred during adolescence in which Pott's disease in early childhood had apparently been cured by a fusion operation. At operation a massive and solid bony fusion of the spine was found, and yet paraplegia occurred in the absence of any demonstrable activity of the disease.

SUMMARY

There have been twenty-eight cases of cord compression complicating scoliosis reported since 1913, and an additional case is reported here. This complication occurs in cases of long-standing scoliosis. Sixty per cent. of the reported cases were congenital in type and 40 per cent. were the result of infantile paralysis. The rapid-growth changes during adolescence and the inability of the spinal cord to accommodate itself to these changes are the likely explanation of the compression, since practically all of the reported cases of paraplegia occurred during this active-growth period. The paraplegia begins with no root symptoms and progresses rapidly. While recovery has followed conservative treatment, laminectomy has resulted in a higher percentage of cures. Prognosis with laminectomy appears to be good. The question of spinal fusion is discussed, but no conclusion is formulated as to whether or not this operation will prevent cord compression.

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TRAUMATIC DEGENERATIVE FIBRILLATION OF THE PATELLA

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Degenerative fibrillation of the patella as a disease entity was first described in this country in 1933 by Kulowski who reported three cases. In 1935 two cases were reported by Slowick, and no other reference to this condition is to be found in the English literature.

Since 1932, the writer has collected five cases, all of which came to operation and in which satisfactory recovery has been made.

Degenerative fibrillation of the patella occurs as a circumscribed area of fissuring and erosion of the articular surface of the patella with loose fibrillae arising from the edges of the fissures. The contiguous portions of the condyles of the femur also show erosion, but seldom fibrillation. In one case the cartilage of the femoral condyle was raised above the surface, so as to fit into a fissure on the patella. Pain referable to the patella is a constant symptom, and most characteristic is the tenderness to patellar pressure in the flexed position. There may be associated with the patellar lesion other pathological conditions such as derangement of the semilunar cartilages, synovitis, joint mice, or slipping patella. Roentgenograms show very little, even with air distention of the joint.

Conservative treatment such as physiotherapy over a long period of time, or the use of immobilizing apparatus even in mild cases, has not brought relief from pain and sense of weakness in the affected joint.

Each of our cases eventually required arthrotomy and removal of the fissured and fibrillated cartilage, together with correction of concomitant lesions when present. In each case a parapatellar incision was used and the patella was everted. The cartilage was shaved off smoothly with a sharp knife, leaving only a transparent film of cartilage covering the bone.

All of the patients made complete recovery and were entirely relieved of pain and disability.

The following cases are typical of this disease. The first illustrates the fact that concomitant lesions are not necessary to produce the fibrillation but, rather, that trauma is the important factor.

CASE 1. E. B., a white female, aged thirty-eight, complained of pain in the right knee following a fall six years earlier. The pain had increased in severity and was very disabling.

Examination showed the right knee to be slightly swollen with a slight amount of joint fluid present. The range of motion was normal. No symptoms were elicited other than pain when pressure was made over the patella. Stereoscopic roentgenographic examination, with air inflation, revealed no pathology. Fluid aspirated from the joint showed nothing pathological. All conservative measures were tried without relief

On October 8, 1932, an exploratory arthrotomy was performed. The only abnormal findings were fissuring and fibrillation of the cartilage of the patella, and a small nubbin raised above the surface of the cartilage on the femoral condyle which came into contact

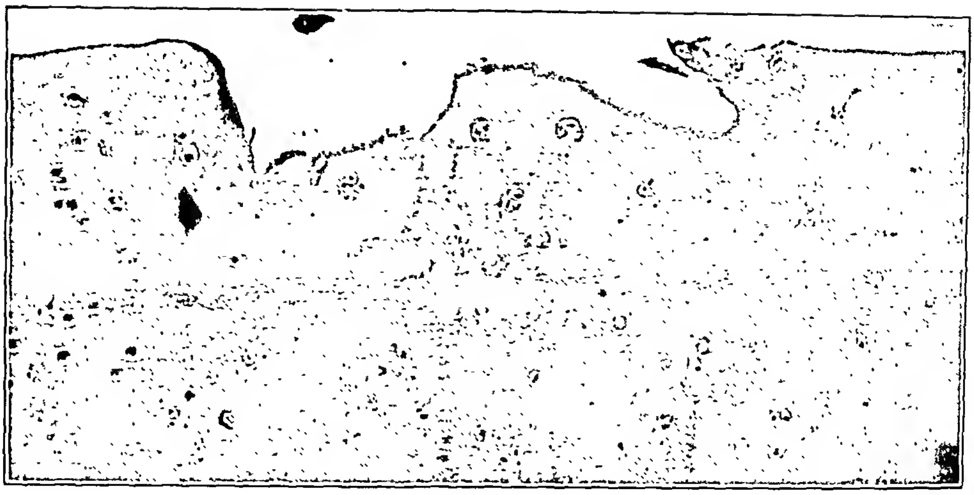

Fig. 1

Case 2. Section showing minute cysts in ground substance.

with the fissure of the patella. The fibrillated cartilage was shaved off nearly to the bone, and the joint was closed.

There has been complete relief from pain with no recurrence to date.

Case 2. Y. S., a white female, aged forty-six, was admitted to the Hospital for Joint Diseases on the Service of Dr. Kleinberg on May 11, 1933. She gave a history of an injury to the left knee eight months previously. Examination showed nothing of interest save marked tenderness to pressure along the medial joint line and a pronounced limp on walking.

An exploratory arthrotomy was done by Dr. Kleinberg on May 13, 1933. The cartilage on the patella was found fibrillated and fragmented. The medial meniscus was loose and was removed. There was fibrillation of the cartilage in the notch between the condyles. This fragmented cartilage was removed and the joint was closed.

The patient made an uneventful recovery and was completely relieved.

Fig. 2

Case 3. Appearance more suggestive of fibrocartilage than hyaline cartilage, due to irritative proliferation.

The pathological report by Dr. Jaffe stated that section of the cartilage removed from the under surface of the patella showed some minute cysts in the ground substance.

CASE 3. E. R., a male, aged seventeen, was admitted on February 8, 1933 to the Hospital for Joint Diseases on the Service of Dr. Kleinberg, with a history of pain, following a day of sport, and a sensation of the presence of a foreign body in the left knee. Roentgenographic examination revealed a sliver of calcified material between the patella and the femur.

Arthrotomy, on February 9, 1933, by Dr. Kleinberg revealed an area of one square centimeter on the under side of the patella bunched up and projecting into the joint. The mass consisted of fragmented and fissured cartilage which was elevated from the underlying bone. This was shaved off and a loose medial meniscus was removed. The wound was closed and the patient made an uneventful recovery.

The pathological report by Dr. Jaffe stated that the section had everywhere the appearance of fibrocartilage rather than hyaline cartilage. It represented irritative proliferation of the surface layers of articular cartilage, as in chronic arthritis, apparently by the action of the perichondrium. Following such proliferation, the new tissue had become detached.

CASE 4. A. L., a female, aged thirty-six, was admitted to the Hospital for Joint Diseases, on November 13, 1934. on the Service of Dr. Kleinberg, with a history of injury to the right knee, which had caused pain and disability. Two years previously a meniscectomy had been performed on the right knee to relieve a similar condition. Since pain and disability had persisted, the patient was advised to submit to reoperation.

Roentgenographic examination on the same day by Dr. Pomeranz showed moderate narrowing of the joint space internally with marginal hypertrophic changes. Slight

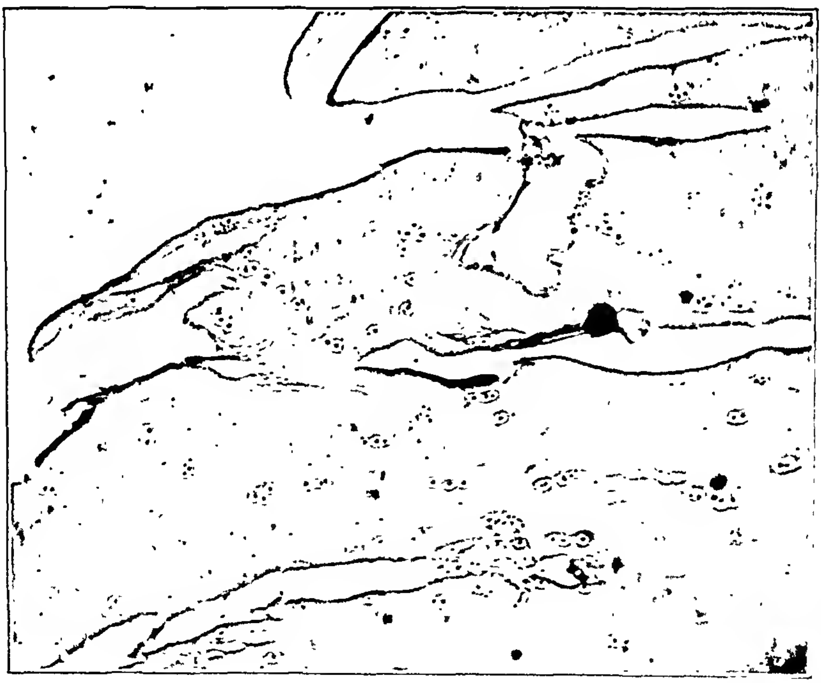

FIG. 3

Case 4. Fibrillated cartilage from articular surface of patella.

lipping was present on the posterior surface of the patella. There was no atrophy or sclerosis.

An exploratory arthrotomy, performed by Dr. Kleinberg on November 14, 1934, revealed a loose body in the joint, and fibrillation of the articular cartilage of the patella and the internal femoral condyle. The external semilunar cartilage was removed. No other pathology was found. The articular cartilage was shaved off and the knee was closed. Uneventful recovery followed.

Microscopic examination of the articular cartilage removed from the patella showed fibrillated articular cartilage.

CASE 5. E. A., a white male, aged twenty-three, was admitted to the Hospital for Joint Diseases on the Service of Dr. Kleinberg on July 5, 1932, because of pain and slipping of the patella. The onset had occurred ten years before, following a severe fall.

The patient walked with a marked limp on the right side; when the knee was flexed, the patella was seen to slip to the outer side and when the knee was extended it slipped back into position. The patella was hypertrophied and the condyle on the outer side felt smaller than that on the inner. Roentgenographic examination showed similar findings, with the additional notation of the presence of several calcified bodies.

Arthrotomy, performed on July 8, 1932 by Dr. Buchman, revealed several loose bodies; these were removed. The cartilage on the inner side of the patella was fibrillated and stringy. This was shaved off close to the bone. The insertion of the patellar tendon was transplanted medially and the external condyle was elevated.

The patient made a very satisfactory recovery and now has no limp, weakness, pain, or disability.

SUMMARY

The five cases of fibrillation of the patella which have been reported are illustrative of a lesion produced by trauma. When not masked by other lesions of traumatic origin, such a lesion gives the characteristic symptom of persistent pain over the patella, which is not relieved until the fibrillated cartilage is removed.

The author wishes to express his appreciation to Dr. S. Kleinberg for the opportunity to study and present several cases treated at the Hospital for Joint Diseases.

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DIASTASIS OF THE SUPERIOR TIBIA COMPLICATED BY GANGRENE

Study of a Case

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This case is presented because of its rarity. In a thorough review of the literature we have been able to find only one reference concerning separation of the superior epiphysis of the tibia,—an article by Gibson who stated that Roberts and Kelly in 1916 had noted that only twenty-six cases of diastasis of the tibia had been recorded. Homans and DaCosta in their text-books state that separation of the superior tibial epiphysis is quite rare, and, as far as we have been able to determine, this is the only case of this nature that has been reported since Gibson's article in 1923. In a review of the records of over 2,000 cases seen in the past ten years on the Fracture Service of the Hurley Hospital, no similar case has been found.

The complication of gangrene following fractures, exclusive of gas-bacillus infection, is likewise unusual. Dodd, in a thorough review of the literature regarding gangrene following fractures, found only thirty-one cases reported between 1850 and 1914, and to this group he added a series of ten cases. Of the thirty-one patients whose cases were recorded in the literature, twenty-seven were males and four were females. Eleven of the cases occurred in males between the ages of sixteen and thirty. Amputations were performed in all but four cases. Complete data were available in twenty-four cases. Dodd reports on these as follows: "Eleven recovered and thirteen died, so that there is apparently a heavy mortality of 54 per cent." Gregora, who has studied this phase of surgery, found only four occurrences of gangrene in 606 fractures, and he stressed largely the steps to prevent gangrene and to save the extremity involved. Further evidence of the scanty information which we have on this subject was given by Ormsby in 1911, who prefaced a report of two cases as follows: "The complication of gangrene is an uncommon one, if I am to judge from the meager references to it to be found in the literature at my command."

CASE REPORT

E. W., aged sixteen years, a schoolgirl, was in an automobile accident on November 17, 1936. She was thrown forward on her knees and the right knee apparently struck an elevation in the floor of the car. When first seen, the patient was conscious and well oriented, and the only positive physical findings were in the right knee. It was noted that the leg below the knee was displaced posteriorly from 50 to 75 per cent., although the knee retained the usual amount of flexibility. The bony prominences of the superior tibia, as well as the pulsation of the popliteal artery, were palpable in the popliteal space.

The leg and foot were not measurably swollen, and the foot was warm, although the dorsalis pedis and the posterior tibial arteries were not palpable. Roentgenographic examination (Fig. 1) revealed a separation of the proximal tibial epiphysis and complete displacement of the diaphysis posteriorly and slightly to the medial side, with a complete avulsion of the tibial tubercle. The fibula was not involved.

The fracture was immediately and easily reduced under gas anaesthesia, and a light plaster-of-Paris dressing was applied. The foot remained warm, although pulsation of the arteries did not return, and a check-up roentgenogram (Fig. 2) revealed a restoration of the proximal epiphysis to an almost normal position, although it remained displaced slightly anteriorly and laterally.

Within twenty-four hours, however, the patient began to complain of numbness in the toes and soreness of the leg. The toes were becoming cyanotic, and the cast was immediately bivalved. At the end of ninety-six hours, the leg was noted to be quite swollen and painful, and the toes were definitely cool. The pain, swelling, tenderness, coolness, and cyanosis were increasing, the calf had become whitish and shiny, and, in view of the increasing discoloration and beginning anaesthesia of the foot, it was felt that a decompression of the popliteal space was indicated.

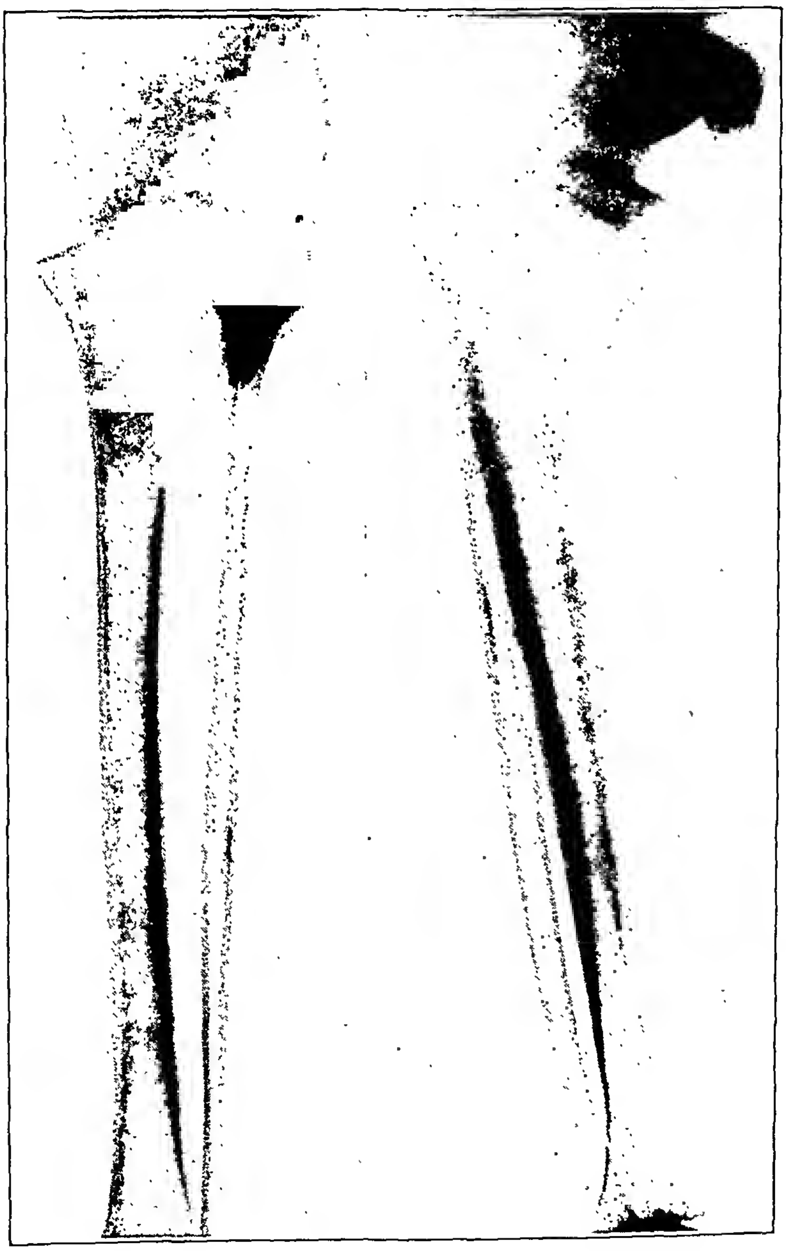

FIG. 1

Condition on admission. Note the posterior displacement of the tibial diaphysis and the avulsed tibial tubercle.

The popliteal space was entered medially, and a large hematoma was removed. The popliteal artery was noted to be pulsating, and there was considerable oedema of the surrounding tissues. In addition, six longitudinal incisions, about six inches in length, were made over the leg laterally, anteriorly, and posteriorly, through the fascia, and into the muscles; these were left open and a drain was placed in

the popliteal space. The leg was subsequently dressed and immobilized in a pillow splint. Observation continued, and the foot became a bit warmer, although, in general, the condition of the leg grew progressively worse. The toes gradually became stiff, blackened, and cold, with considerable shriveling; the calf remained swollen, the long incisions were discharging seropurulent material, and the fascial planes were showing grayish discoloration; complete anaesthesia existed over the entire foot. (See Figures 3 and 4.) In view of the patient's weakened condition (temperature from 100 to 103 degrees daily from November 18, 1936 to December 3, 1936), supportive measures were carried out, which included the indirect transfusion of 500 cubic centimeters of citrated blood on three occasions. However, the patient's condition became steadily worse, and a midthigh amputation was decided upon and done as a life-saving procedure on December 3, 1936, under nitrous-oxide anaesthesia. This procedure was preceded by a third

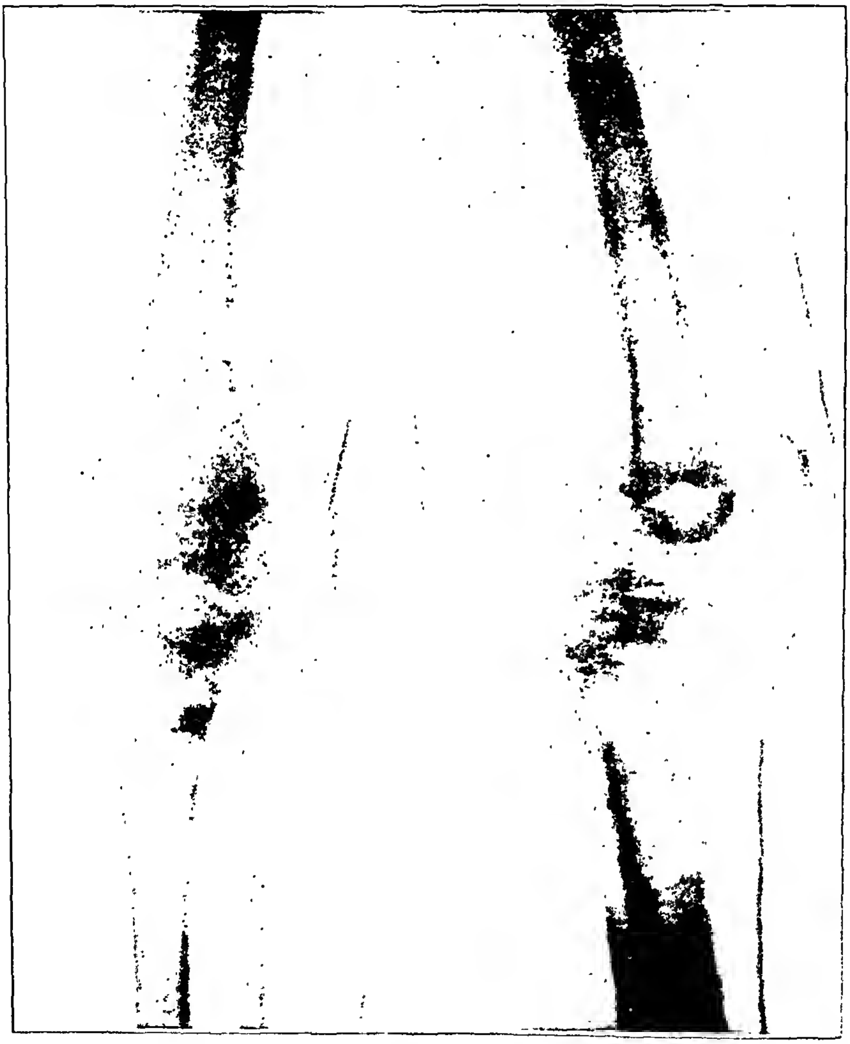

Fig. 2

After reduction. Note the restoration of the proximal tibial epiphysis to an almost normal position.

Fig. 3

Third postoperative day. Note the discoloration of the leg with medial and anterior incisions.

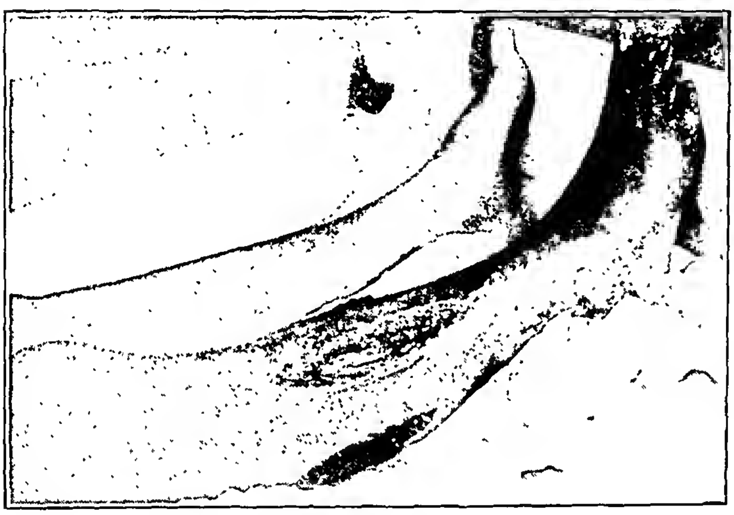

Fig. 4

Third postoperative day. Note the discolored leg, foot, and toes, with shriveling of the latter.

transfusion of 500 cubic centimeters of citrated blood.

The patient's temperature immediately returned to normal and remained there throughout the postoperative course which was entirely uneventful. The wound at the stump healed by primary intention, and the patient was discharged in excellent condition on December 20, 1936.

DISCUSSION

The bifurcation of the popliteal artery is anchored by the fibrous arch of the soleus, by the passage of the anterior tibial artery over the interosseous membrane, by its proximity to the fibula, and by the origin of small anastomotic branches to the knee joint. The comparatively intimate association of the bifurcation with the neck of the fibula has been noted,—*i.e.*, on the inside of the neck of the fibula there is a slight groove which is made by the anterior tibial artery as it passes from behind to the front part of the leg. This emphasizes the vulnerability of the artery in fractures in this region of the fibula.

The anterior and posterior tibial arteries are also close to the fibula, particularly in the upper third of the leg, and furthermore they lie on, or are covered by, aponeurosis,—in other words, the anterior and posterior tibial arteries are in reality closer to the fibula than to the tibia. Muir's case of a fracture of the upper third of the fibula followed by gangrene illustrates this point.

The pathological report of the case which has been described was as follows: "The specimen consists of an oedematous leg (right), which has been amputated at the middle third of the thigh. The toes show a dry gangrene. There are longitudinal incisions in the popliteal space and in the

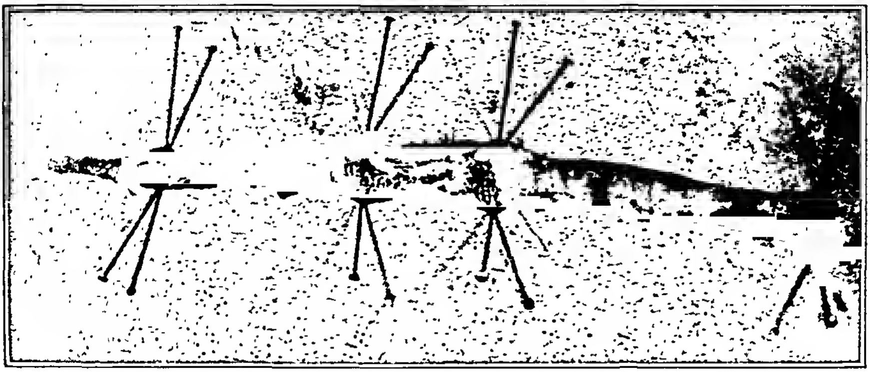

Fig. 5

Dissected popliteal artery. Note the constricted area proximal to the bifurcation with discolored thrombosis above the narrowed lumen.

upper and middle thirds of the calf. There is a serosanguineous exudate from these incisions.

"The distal end of the femoral artery was found and dissected down to the bifurcation of the popliteal into the anterior and posterior tibial arteries. About two centimeters above this bifurcation there was a marked area of constriction and just above this was a firm, discolored area which was two and one-half centimeters in length. On sectioning the artery throughout its entire length, this discolored region was found to be an area of thrombosis with a distal constriction of the popliteal artery. [See Figure 5.]

"On further dissection of the leg, the entire venous system was so necrotic that it was impossible to dissect out the veins as such. The popliteal space was completely filled with old clotted blood which extended anteriorly to the interosseous septum. All of the tissues of the leg were oedematous and showed beginning necrosis."

In this case, the postreduction diagnosis was obvious, inasmuch as the usual signs of interruption of blood supply (absence of arterial pulsation, anaesthesia, swelling, etc.) were present. The time of onset of gangrene is apparently on the third to the sixth day, ordinarily on the fourth. As noted, the gangrene began to develop in this case on the third day. The actual etiology of the vascular interruption in this case apparently was a venous oozing at the site of the original trauma, followed by a subsequent thrombosis of the artery (ante-amputation diagnosis).

SUMMARY AND CONCLUSIONS

This dramatic case presented three phases in its management: (1) a reduction of the fracture-dislocation, which was accomplished easily and satisfactorily; (2) efforts at saving the leg by the decompression procedures previously described; (3) the imperative necessity of saving the patient's life by amputation.

If a similar case should present itself, we feel that this same manage-

ment would be resorted to, with the possible exception of earlier intervention in the second and third phases.

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FURTHER OBSERVATIONS ON TREATMENT OF FRACTURE OF THE CARPAL SCAPHOID (NAVICULAR)

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During the past ten years the problem of treatment of fracture of the carpal scaphoid has been receiving increased attention. In 1928, Adams of Boston introduced the use of the bone graft and not long afterward Murray of Toronto suggested the present-day technique,—namely, the use of the bone peg. A few years ago a study of fractures of the carpal scaphoid treated at the leading industrial clinics in Boston showed that the results obtained left much to be desired. In 1934, the author reported his experience with both the bone-graft and the bone-peg operations. Sufficient time has now elapsed to show definite end results over a period of from four to seven years in the cases reported at that time. It is the purpose of this paper to record the final results in these cases and to present other representative cases.

During 1934, 1935, and 1936, 100 patients with fracture of the carpal scaphoid were treated in the Out-Patient Department of the Boston City Hospital. Six of these were females, and 48 per cent. of them were twenty years of age or under. We are, therefore, dealing with a condition that affects young people and one that should be treated early and correctly.

TREATMENT

Sprained wrists in which the pain is sufficiently severe or localized to make one suspicious of a fracture of the scaphoid should be protected from the start, either by an anterior wooden splint or by a leather wrist strap large enough to include the hand and a good part of the forearm. If later roentgenograms show a fracture, suitable treatment will have been instituted early and properly maintained by the leather wrister. A sprained wrist which does not clear up in a month's time should be x-rayed again with a possible fracture of the scaphoid in mind. If this is done, further trouble will be saved in many cases. Often roentgenographic examination will be negative immediately following the injury, only to show a fracture a month later. Many fresh cases show a very fine fissure fracture which is often overlooked by physicians unfamiliar with it and which, untreated, may show a heavy line of absorption within a very few months. The following case is illustrative of this condition.

CASE 1. T. C., male, aged thirty-four, a laborer, injured his wrist on May 20, 1932, while lifting a roll of paper. Roentgenographic examination (Fig. 1-A) showed a fissure fracture, and the patient was treated with anterior and posterior splints for from four to five weeks, followed by baking and massage. He was out of work for approximately four months. In July 1933, he was reexamined because of the condition of his wrist.—

namely, pain, weakness, inability to push or to flex the wrist dorsally. The roentgenogram taken at that time (Fig. 1-B) showed marked absorption. The patient was operated upon in another clinic where an inlay graft was used. The wrist was immobilized for four weeks and the patient was allowed to return to work in five weeks. The end result was very poor, due undoubtedly to his returning to work too soon and too brief a period of splinting.

Fig. 1-A

Case 1. T. C. May 20, 1932. Fissure fracture of scaphoid.

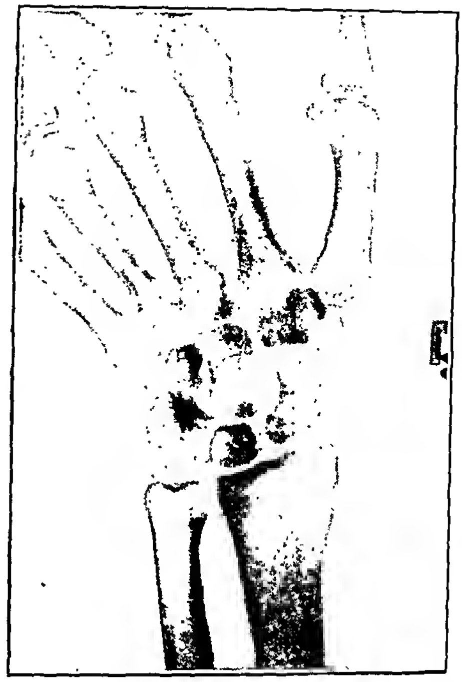

Fig. 1-B

Case 1. T. C. July 1933, fourteen months later, showing line of absorption.

If the diagnosis of a fracture has been made in a fresh case, the treatment should consist of immobilization in plaster and rest, with the hope that bony union may occur. There is considerable difference of opinion as to just how the hand should be held at this time; many use the cock-up position, with radial deviation and with slight abduction of the thumb, while others use the reverse,—slight volar flexion with radial deviation. From personal observations and work with Dr. F. J. Cotton and Dr. D. D. Berlin, we have found it best to use dorsal flexion.[3] In these cases, the plaster-of-Paris cast is used instead of the ordinary cock-up splint. This immobilizes the wrist, does not require adjustment when properly applied, and ensures the patient of a continuance of the treatment. Often, with the metal cock-up splint, the patient gives up the treatment at the end of two or three weeks and is never seen again. In this way, one not only loses the patient, but the splint as well. Regardless of how it is obtained, immobilization should be maintained for at least six weeks, followed by baking and massage for a few weeks. Too much emphasis cannot be placed on the need of six weeks' immobilization. Less time, in our opinion, is entirely inadequate.

The cast is applied in the cock-up position with slight radial flexion

to include the palm of the hand and the base of the thumb, but this does not limit the motion of the fingers. Some feel that it is better to include in the cast the distal joint of the thumb with marked abduction, thereby assuring better and closer approximation of the fragments. Following the removal of the cast, a straight splint may be applied for a few days, after which a flannel bandage is substituted and motion is started at once.

Most of these cases, if seen within forty-eight hours following trauma, will do well under this routine. The mistake most commonly made is the shortening of the period of absolute rest. In fresh cases, treated as described, if the results are not satisfactory at the end of four months—and most of them are at the end of three months—they are very apt to grow more and more unsatisfactory. There is no harm in waiting a while longer, but in our experience these cases will not improve and it will be necessary to resort to an operation. We do not feel that enough of these cases, either treated or untreated, are operated upon.

In the second group of cases where there is marked separation of the parts, we believe that it is possible to reduce the fracture and to peg the fragments instead of resorting to operative removal. This type of fracture, usually associated with a crushing of the soft tissue, is very rare.

In the third group of cases the wrist is crippled by months of use, with the resultant pain and weakness so frequently seen. This group represents the cases, usually untreated or poorly treated, that have gone on to malunion with bone formation along the radial styloid. (See Figure 2.) If the patient is engaged in an occupation requiring the constant use

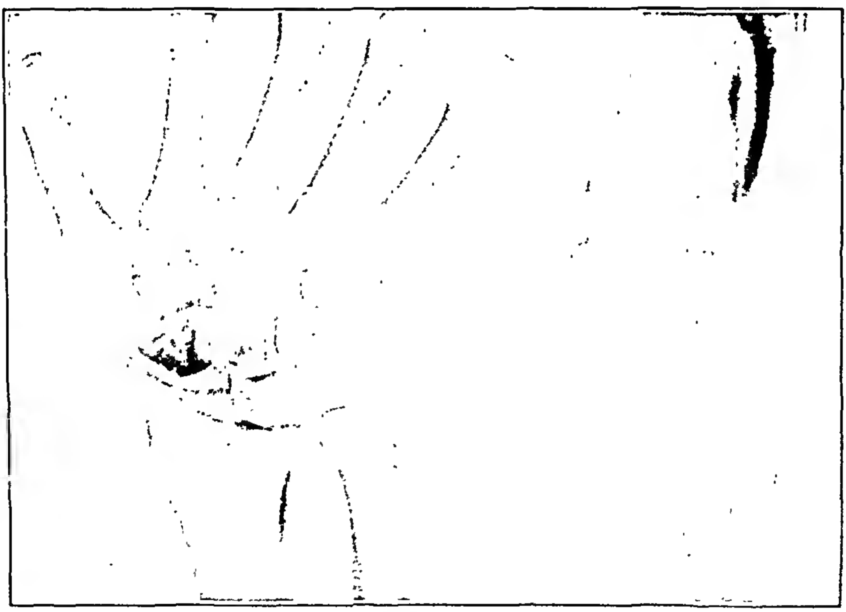

Fig. 2

Old fracture with elongation of styloid.

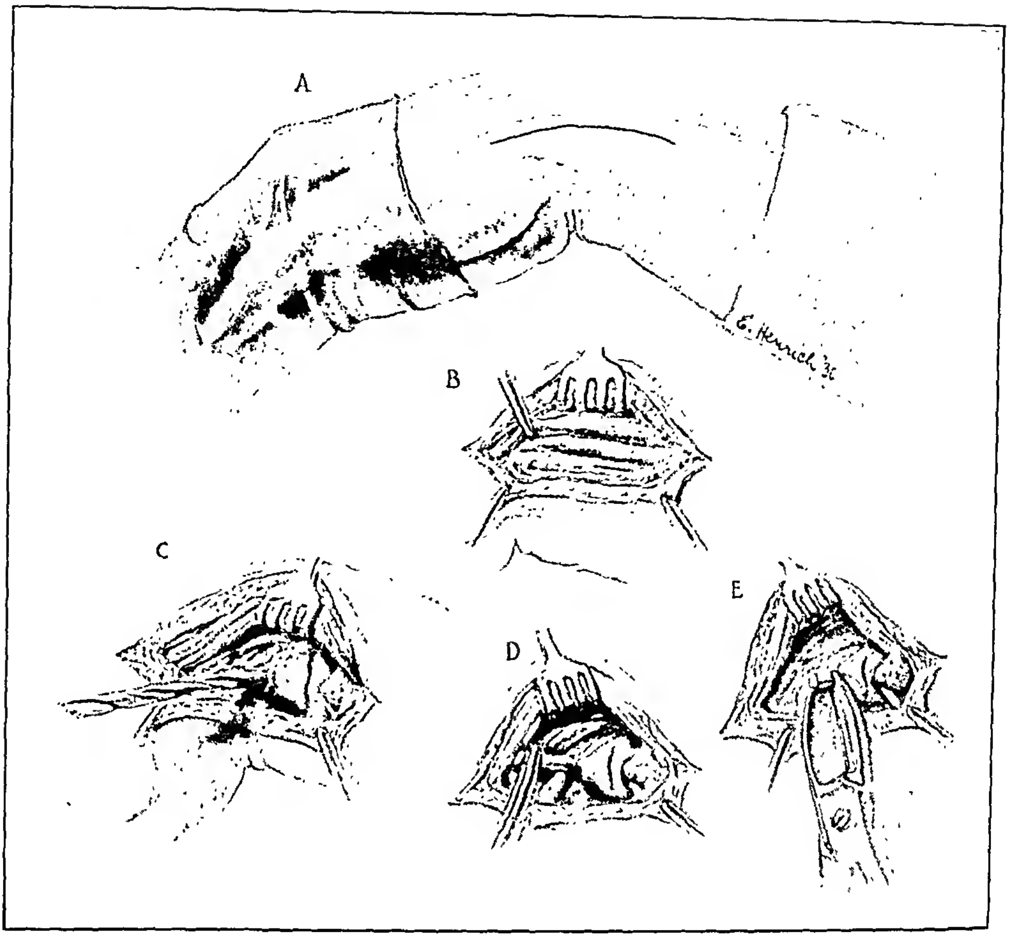

Fig. 3
Operative technique.

of the wrist, this injury leaves him almost totally disabled from the standpoint of earning his living along the lines to which he is accustomed. The following operation is recommended for this type of case.

OPERATIVE TECHNIQUE

The best incision is the lateral one made midway between the palmar and the dorsal aspects of the radius, usually from one and one-half to two inches in length, avoiding the palmar side of the wrist because of the danger of hemorrhage, with retraction of the tendons upward. (See Figures 3, *A* and 3, *B*.) The styloid of the radius is always used as a landmark for locating the scaphoid. Much has been written about operating on the wrong bone, and many mistakes have been made and continue to be made —such as removing the semilunar, drilling the trapezium, etc.—but these errors can be avoided by making use of the radial styloid. Another absolute check is to observe the fracture line in the scaphoid which is obvious through this incision. After the joint has been opened, the wrist is then placed in acute palmar flexion with some radial deviation (thereby placing most of the scaphoid in the middle of the wound) and held there by an assistant with the aid of a sandbag placed under it. A drill hole, a quarter of an inch in diameter, is made according to the technique of

Murray. (See Figure 3, *C*.) In drilling this hole, care should be exercised not only in regard to the direction of the hole but also to the depth. Occasionally the drill runs over into the semilunar. The bone peg used to stabilize the fragments and to stimulate union is taken from the tibia

FIG. 4-A
Case 2. D. A. L. April 7, 1930.

FIG. 4-B
Case 2. D. A. L. January 25, 1937. Fibrous union.

FIG. 5
Case 3. P. O. January 21, 1937. No union.

Fig. 6-A
Case 4. H. S. B. April 12, 1934.

Fig. 6-B
Case 4. H. S. B. January 30, 1937. Fibrous union.

rather than from the radius and is fitted with rongeurs to the drill hole. (See Figure 3, *D*.) After this peg has been tapped in as far as desired, the excess is cut away with bone forceps and the wound is sutured in layers. (See Figure 3, *E*.)

In two cases roentgenographic examination, together with clinical signs and symptoms, gave evidence of a fracture, but operation failed to reveal it. Both of these cases were treated in the usual manner,—namely, drilling and pegging. The results were excellent, with complete relief from symptoms.

CASE REPORTS

CASE 2. D. A. L., male, aged forty-seven, a chauffeur-mechanic, fell in August 1929, injuring his wrist. He wore a leather splint for two months without relief. In February 1930 he complained of pain, weakness, and inability to push. An inlay-graft operation was performed in April 1930, and the wrist was immobilized in plaster for ten weeks. Figure 4-A shows the condition before operation and Figure 4-B, taken in January 1937, shows the end result. This appears to be a fibrous union. Clinically, except for a slight limitation of dorsal flexion, it is an excellent result.

CASE 3. P. O., male, aged seventeen, a student, injured his wrist while playing football in November 1931. He had little or no treatment. A bone-peg operation was performed in July 1932, and a plaster cast was applied for eight weeks. Figure 5 shows the

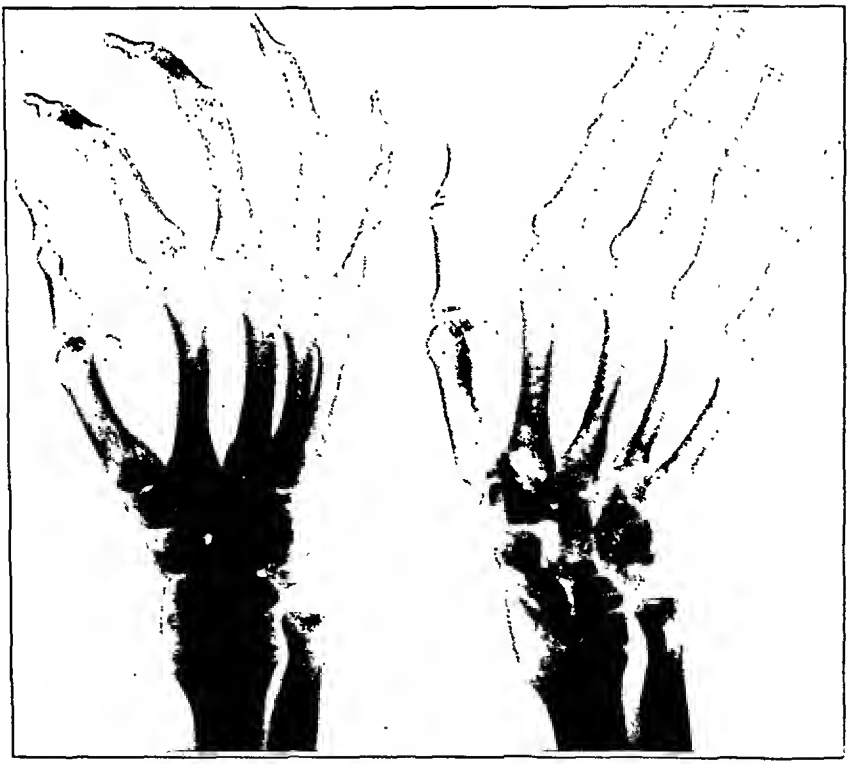

FIG. 7

Case 5. G. C. January 19, 1937. Bony union.

condition on January 21, 1937. From the anteroposterior view, one would believe that there was bony union, but the oblique view shows a black line between the fragments, or absolutely no union. Dorsal flexion was limited; otherwise, an excellent clinical result was obtained.

Case 4. H. S. B., female, aged eighteen, fell and injured her wrist. Eight months later, in April 1934 (Fig. 6-A), a bone-peg operation was performed. The wrist was immobilized in plaster for seven weeks, followed by an anterior splint for ten days.

Fig. 8-A

Case 6. F. T. March 22, 1935. Bone peg inserted into semilunar through scaphoid.

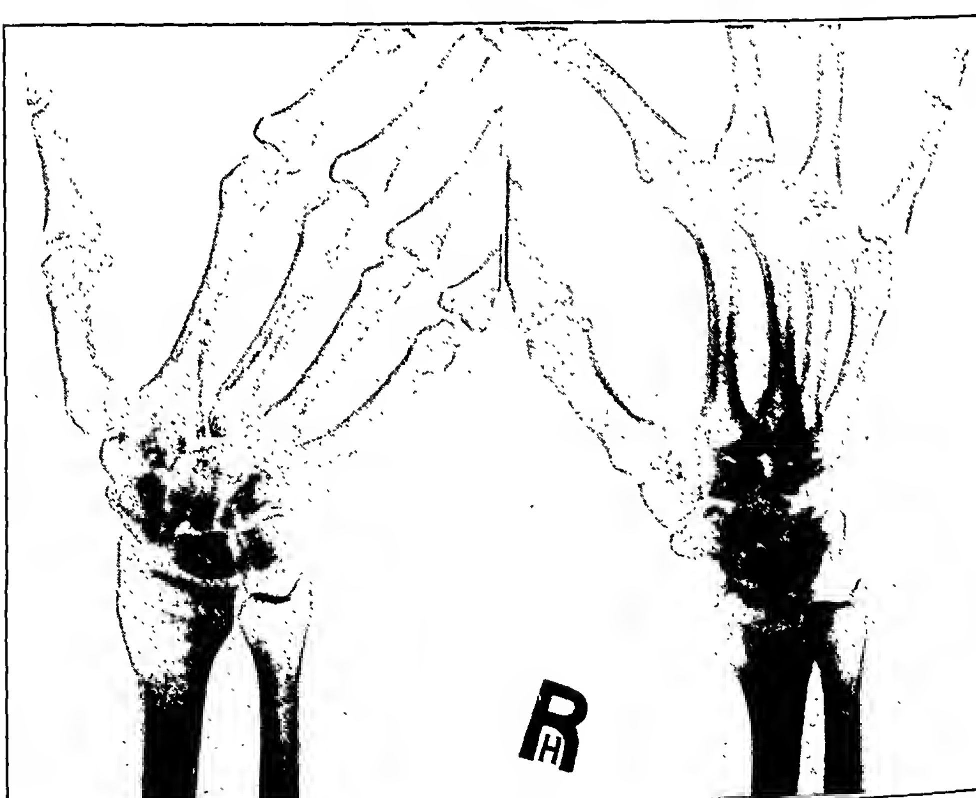

Fig. 8-B

Case 6. F. T. January 22, 1937. Bony union.

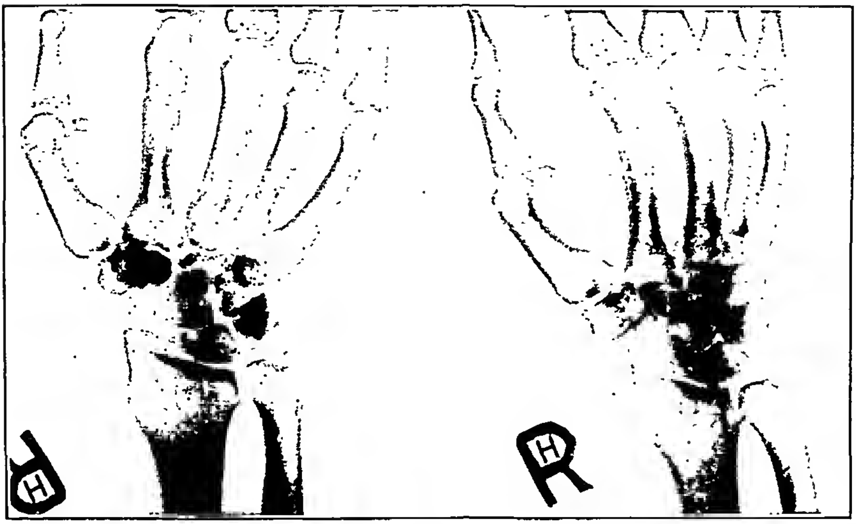

FIG. 9

Case 7. A. D. End result following operative removal of scaphoid.

Roentgenographic examination in January 1937 (Fig. 6-B) showed fibrous union. The clinical result is excellent.

CASE 5. G. C., male, aged twenty, fell while roller-skating, landing on his right hand. This was followed by a moderate amount of pain in the wrist. He was told at the Relief Station that there was no fracture. During the following year he continued to complain of pain on motion, especially marked when playing baseball. A bone-peg operation was performed on August 15, 1936. Roentgenographic examination on January 19, 1937 (Fig. 7) showed bony union. The clinical result is excellent.

CASE 6. F. T., male, aged twenty-one, injured his wrist while diving. Six months later, on March 22, 1935, a bone peg was inserted into the semilunar through the scaphoid. (See Figure 8-A.) On January 22, 1937, a check-up roentgenogram (Fig. 8-B) showed apparent union of the scaphoid and the semilunar. An excellent clinical result was obtained.

CASE 7. A. D., male, aged thirty-five, fell and fractured the carpal scaphoid. The fracture was inadequately treated and a chronic condition developed, necessitating the removal of the scaphoid. (See Figure 9.) Clinically, a reasonably good result was obtained, but there was a marked change in the anatomy of the wrist.

CASE 8. E. B., male, aged twenty-six, fell backward on April 23, 1934, sustaining a bilateral fracture of the carpal scaphoid, with dislocation of the proximal row of carpal bones. (See Figure 10-A.) On May 1, 1934, by means of Soutter traction under ether anaesthesia for fifteen minutes and a Thomas wrench, the fracture was reduced. (See Figure 10-B.) The wrist was placed in anterior and posterior splints for five days and later in a cock-up plaster cast for nine weeks. This patient disappeared and no further roentgenograms were obtainable. A satisfactory result is said to have been obtained.

SUMMARY

In summarizing, we wish to stress the following points:

1. In all suspicious cases, and in checking the end results for union, the oblique view is most important.

FIG. 10-A

Case 8. E. B. April 23, 1934. Dislocation of first row of carpal bones, with fracture of scaphoid.

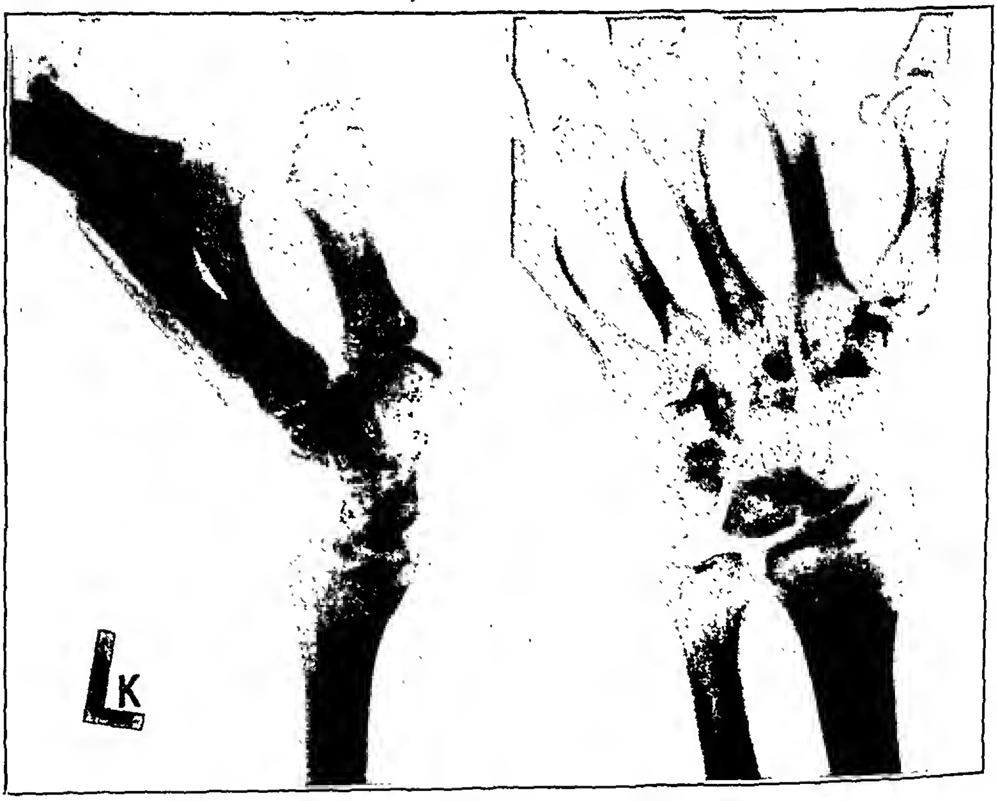

FIG. 10-B

Case 8. E. B. June 27, 1934. Following reduction.

2. The final result as shown by the roentgenogram varies between no union, a possible fibrous union, and bony union.

3. The end result should be evaluated by the clinical findings and not by the roentgenograms.

4. The results obtained both by the bone-graft and the bone-peg operations clearly prove that it is no longer necessary to remove the scaphoid.

5. The bone-peg operation, which is much easier to perform, leaves the anatomy undisturbed, the wrist strong and free from disability other than some limitation of dorsal flexion, and the patient satisfied.

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FIG. 3
Anteroposterior view, showing dislocation reduced.

FIG. 4
Lateral view, showing dislocation reduced.

from the tibial tubercle to the toes. Roentgenograms, taken the next day, revealed complete reduction of the dislocation. (See Figures 3 and 4.) At the end of ten days the plaster splints were discarded and an Unna boot was applied to the foot and leg, at which time the patient had a range of only 15 degrees of ankle motion. He was discharged from the Hospital and referred to the Orthopaedic Clinic.

We lost sight of him for the next five months. He next appeared at the Clinic on March 3, 1937 and gave a complicated history of having been elsewhere. He stated that he had worn a cast for five weeks and had then been given baths and passive ankle motion plus baking and massage. He stated that after a day's extensive walking he sometimes had slight ankle pain. There was a slight suggestion of a limp in his gait which we ascribed to habit at this stage. His range of ankle motion had increased considerably over the 15 degrees which he had on discharge from the Hospital. He now had active flexion-extension ankle motion from 95 to 135 degrees, which may be considered normal.

DISCUSSION

While fractured ankles are very common and dislocation results in about 20 per cent. of these cases [4, 9], it is very rare to find dislocation of the ankle uncomplicated by fracture, such a condition having been reported by only six authors in the last ten years.

Consensus of opinion [3, 7, 8] as to the mechanism of these dislocations is that they occur when the plantar-flexed foot meets a sudden obstruction, as in alighting. Plantar flexion with the body weight pushing the tibia downward and forward favors dislocation, because the astragalus fits more loosely in the mortise in this position. A fall on the plantar-flexed foot sometimes results in a backward displacement of the astragalus with the mortise sliding into the dorsum of the foot. Sometimes the astragalus is pinched from behind by the ground impact pushing up from below through the calcaneum. This pinching causes the astragalus to be

propelled forward out of the mortise much in the same fashion that a slippery melon seed is squeezed from between the fingers. Displacement inward or outward depends upon whether the foot is in the position of varus or valgus at the time of impact. This propulsive type of dislocation is frequently accompanied by rotation of the astragalus about its long axis. Sometimes[4, 9] the inferior articular surface of the astragalus rotates as much as 180 degrees and articulates with the mortise. Such injuries naturally interfere materially with the blood supply of the astragalus. Schmitt has reported necrosis of the astragalus following injury.

As in our case, reduction may often be easily accomplished by manipulation. On the other hand, Hirschfield, Pegreffi, and Schmitt found operative reduction the solution in their cases. Pin traction or operative reduction have been necessary in more complicated cases[3, 5, 8].

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AN OPERATION FOR MENISCECTOMY OF THE KNEE

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Early in 1932 the author was forced to reoperate on three knees in close succession and in each case to remove the posterior third of the lacerated meniscus, incompletely removed at a previous operation. Because of this unfortunate circumstance, the writer immediately began using two separate incisions into the knee joint in all meniscus operations, so as to remove completely the torn cartilage and to obviate the danger inherent in leaving the posterior portion in the knee. In May 1934, while operating on a large cyst of the meniscus and following the cyst backward through an oblique anterior skin incision, it was found possible to retract the skin, with the knee flexed, and to enter the capsule behind the collateral ligament through a second capsule incision. Since that time, the single skin incision with a double capsule incision has been used and all menisci have been removed entirely and completely.

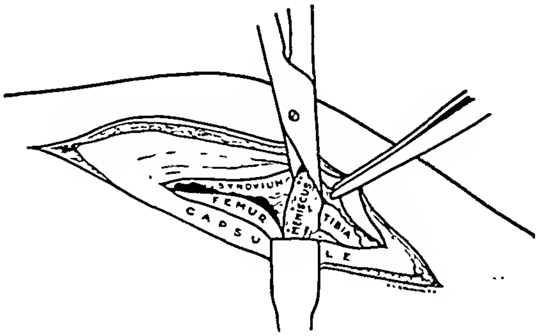

FIG. 1

Diagram of operative procedure, showing the anterior skin and capsule incision, the base of the meniscus being freed in front, and the blades of the scissors above and below the meniscus.

As will be seen from a consideration of the bibliography, opening the knee joint anteriorly and posteriorly at one operation is not a new procedure, but at the present time it is not commonly employed. The present report is for the purpose of emphasizing the necessity for complete removal of the meniscus, of showing the sim-

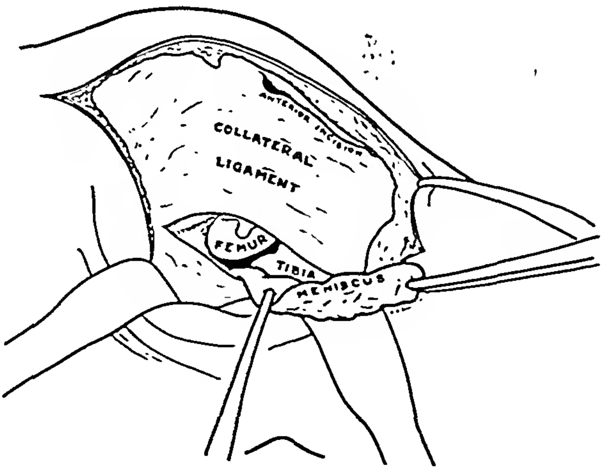

FIG. 2

Diagram of operative procedure, showing the knee flexed, the skin and subcutaneous tissue with the patellar branch of the saphenous nerve drawn backward, and the posterior capsule incision exposing the posterior compartment of the joint and the meniscus.

plicity of a double capsule incision with a single skin incision, and of corroborating previous reports as to the same uneventful convalescence as is secured with a single incision.

OPERATIVE TECHNIQUE

The first step of the operation consists of an oblique incision slanting upward and slightly backward over the anterolateral or anteromedial aspects of the joint, depending upon which meniscus is to be removed. Such an incision will avoid injury to the patellar branch of the saphenous nerve, since it parallels the course of this nerve. The skin and subcutaneous tissue can be drawn forward and the capsule opened at the usual point anteriorly, in line with its fibers, by a vertical incision. (See Figure 1.) The synovium above the meniscus should be opened between two pairs of forceps, care being taken not to mark or to cut the articular surface of the underlying femoral condyle. The small synovial pouch below the meniscus, between it and the tibia, should be opened in similar fashion. By means of curved scissors, one blade of which is placed above and the other below the meniscus, the anterior end of the meniscus can be freed from the synovium and the coronary ligament. In like manner, the base of the meniscus can be dissected free from its attachment to the collateral ligament. The knee is then flexed and the skin and subcutaneous tissue are dissected backward from the collateral ligament close to the capsule of the joint. The capsule is opened over the posterolateral margin of the femoral condyle behind the collateral ligament by a vertical incision in line with its fibers. The anterior portion of the meniscus is then passed backward under the collateral ligament, and its posterior third can be well visualized extending into the back of the joint. (See Figure 2.) The posterior third is freed from its attachment with scissors as far back as the posterior tibial spine. If a good view of the extreme posterior tip cannot be ob-

FIG. 3

Triple bucket-handle fracture of a meniscus which was removed intact through the incision described.

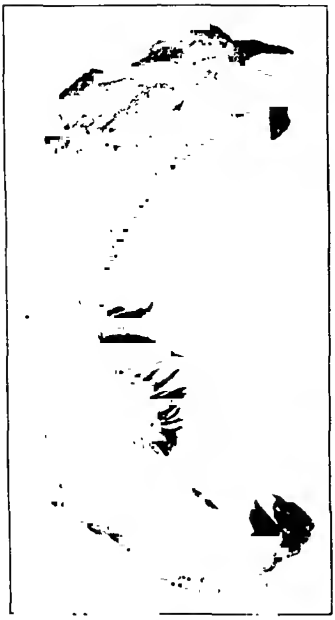

FIG. 4
Unusual fringed laceration of a meniscus which was removed intact.

FIG. 5
Laceration and cyst of a medial meniscus which was removed intact through the incision described.

tained, it can be divided by a tonsil snare, thus avoiding any danger of laceration of the posterior crucial ligament.

When the knee is straightened, the posterior incision will be found to close tightly. No sutures have been used on the posterior capsule incision in the past fifteen cases and no trouble has been experienced in this respect. The anterior incision is closed with interrupted fine silk sutures, care being taken to draw the subpatellar fat pad out of the joint by including a portion of it in the suture. The skin and subcutaneous tissue are closed with interrupted silk, and a dressing wrung out of Dakin's solution is applied with a pressure bandage. The pressure bandage is cut two hours later and the knee is rebandaged.

END RESULTS

The technique described has been used in twenty cases with no prolongation of convalescence and without causing joint relaxation or lack of mobility. Patients have been relieved of the necessity of a second external scar, and compensation schedules show losses lower than those in cases with two external scars. Three knees have been completely opened on both sides at the same operation by two skin incisions and four capsule incisions, so that in each case the knee joint could be explored. Convalescence in all three cases was the same as in cases where a single skin and capsule incision has been employed. Examples of unusual menisci removed intact by this procedure are shown in Figures 3, 4, and 5.

SUMMARY

The operative procedure which has been presented allows complete removal of a meniscus of the knee through a single skin incision and a double capsule incision, avoiding the possibility of injury to the patellar branch of the saphenous nerve and the presence of a second skin cicatrix. All lines of incision are in the direction of tissue structure and are so located as to avoid strain on knee motion.

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OSTEOGENIC SARCOMA OF THE ASTRAGALUS

Report of a Case

BY OTHO C. HUDSON, M.D., F.A.C.S., HEMPSTEAD, LONG ISLAND, NEW YORK

Osteogenic sarcoma is the most frequent malignant bone tumor. The long bones are most often attacked, while the small bones are relatively immune.

CASE REPORT

V. W. (patient of Dr. E. C. Braynard), white, male, twenty-two years of age, a student, was seen by the writer in September 1934.

In April 1934, the patient had had a gradual onset of pain in the dorsum of the right foot with swelling. The pain had become worse in May and weight-bearing was stopped.

Fig. 1

Roentgenogram of the right foot, taken on May 8, 1934, showing soft-tissue swelling.

FIG. 2

Roentgenogram of the right foot, taken on August 17, 1934, revealing a tumor arising from the neck of the astragalus.

FIG. 3

Right foot after amputation, showing the tumor arising from the neck of the astragalus.

There was a constant ache in the foot, but it did not keep him awake at night. The pain had become steadily more severe.

Examination on September 7, 1934, revealed atrophy of the right thigh and calf. There was enlargement of the ankle and the foot with marked limitation of all motions in the ankle. The foot was held in the valgus position. There was marked induration of the periarticular structures about the ankle and the midtarsus. Marked tenderness was present over the astragalus. A small hard mass was felt over the dorsal surface of the astragalus.

Fig. 4

The partly dissected foot, showing the tumor at the point of the hemostat.

A roentgenogram of the right foot, taken on May 8, 1934, revealed a soft-tissue swelling beneath the external malleolus. A later roentgenogram, taken on July 20, 1934, disclosed marked decalcification of all the tarsal bones. Considerable soft-tissue swelling was noted over the anterior portion of the ankle. There was an apparent area of erosion of the dorsal surface of the astragalus. A further roentgenogram, taken on August 17, 1934, showed increased decalcification of the bones. A tumor mass could be seen over the neck of the astragalus, with a definite destruction of the cortex beneath.

Roentgenographic examination of the chest was negative. The Wassermann test and the urine were also negative. Blood count showed:

Red blood cells—4,600,000
Hemoglobin—90 per cent.
White blood cells—14,900
Polymorphonuclear neutrophiles—77 per cent.
Large lymphocytes —17 per cent.
Small lymphocytes — 6 per cent.

On September 11, 1934, under a double tourniquet, a dorsal incision was made over the ankle into a tumor which was found to be highly vascular, gray, and granular. On frozen section a diagnosis of osteogenic sarcoma was made. An amputation was then done at the level of the upper third of the thigh.

The pathological report by Dr. J. S. Grewal was as follows: "The tissue is firm, friable, granular, and reddish-gray in color. There is a medial dorsal incision over the ankle extending down and exposing a broken-down, brownish, friable tumor mass

continuous with the astragalus. The tumor measures about three by two centimeters in diameter on the surface. The soft tissue about the tendons in this region is oedematous.

"Microscopic examination of the section of the piece of tissue reveals a moderately cellular structure. The cells are polyhedral and are arranged in a most disorderly fashion. In places quite a little fibrillar substance is deposited around them. In still other places the cells are elongated and closely packed. Numerous anastomosing strands of calcified portions of the tissue are also present. Some of these areas are definitely ossified. Scattered throughout the tissue a number of multi-nuclear giant cells are present. Only occasional mitotic figures are seen. The blood vessels are also quite numerous, but their walls are thick and old."

The wound healed by first intention and on November 30, 1934, the patient was fitted with an artificial extremity. Roentgenographic examination of the chest on August 22, 1936, was negative. When last seen on April 22, 1937, the patient was in good condition with no complaints. He has been working continuously and regularly.

Tumors of the astragalus are very infrequently encountered. The Registry of Bone Sarcoma of the American College of Surgeons have three cases, including the one described which is registered as No. 1809. In all three cases the patients had the same initial symptoms, and there was a long interval from onset until the time of diagnosis. The roentgenographic interpretation and the histological findings were almost identical. From the histology, a better prognosis for life was given in each case than is usual in the same tumor of the long bones.

It would seem, from these few cases, that a five-year cure might be obtained in an osteogenic sarcoma of the astragalus.

REPAIR OF LACERATION OF FLEXOR POLLICIS LONGUS TENDON *

BY FRANK G. MURPHY, B.SC., M.D., F.A.C.S., CHICAGO, ILLINOIS

From the Department of Orthopaedic Surgery, University of Illinois College of Medicine

Laceration of the flexor pollicis longus tendon occurs so frequently, and function of the hand is so irreparably damaged by omission of its repair or by injuries to other muscles during the surgical repair, that it deserves special consideration. More difficulty is encountered in approximation of the severed ends than in any other tendon of the hand. H. P. Maloney states that the injury is usually caused by a stab wound from glass or porcelain handles on faucets. The patient when turning a faucet that is slightly stiff uses more exertion than ordinary and presses against the glass handle, sometimes with a considerable portion of his weight. The glass handle breaks obliquely and the point stabs directly into the palm, frequently into the thenar eminence of the hand. Several deeper structures are usually injured, but the one that is most frequently damaged and that is the most important is the flexor pollicis longus tendon.

The tendon lies deep in the hand, gliding over the first proximal phalanx and over the first metacarpal bone. It lies inside the outer head of the flexor pollicis brevis and to the inner aspect of the abductor pollicis and the opponens pollicis muscles. The last three muscles are supplied by branches from the median nerve. The tendon lies outside the adductor pollicis and the inner head of the flexor pollicis brevis, which are supplied by the ulnar nerve. It then courses upward under the annular ligament in its own compartment. In the wrist, the tendon lies under the median nerve, deep in the groove between the flexor carpi radialis and the palmaris longus tendons. It blends into its muscle from one and one-fourth to two inches above the annular ligament. Throughout its course, it has its own tendon sheath and its own mesotendon posteriorly.

A study of the pathogenesis explains several complicating features. When this tendon is severed in the palm, the proximal end retracts for a considerable distance and goes well up under the annular ligament. The reason for the extensive retraction of this tendon is its complete separation from other tendons which might exert some restraint in its course. No other single tendon in the palm retracts to such a great extent.

The diagnosis of this condition is made on the history of a recent injury, the presence of a wide or small deep laceration in the palm, and the loss of voluntary flexion of the distal phalanx of the thumb. Examination of the wound may reveal the distal end of the tendon in the

* Presented before the Chicago Orthopaedic Society, January 1935.

wound if the distal phalanx is passively sharply flexed, but the proximal end cannot be found in the wound regardless of flexion of the wrist, elbow, or hand.

The usual procedure in these cases is to dissect from the wound upward. In the effort to secure the proximal end of the tendon, rather extensive dissection is necessary and causes considerably more injury to the muscles of the thenar group. The greatest danger lies in the possibility of trauma to the branch of the median nerve to the thenar group. Eventually dissection has to be carried up under the annular ligament, which is cut to expose the tendon. After the tendon ends have been sutured and an attempt has been made to approximate all the structures cut or disturbed in the dissection, there frequently results more trauma than was imposed by the suturing of the original severed tendon.

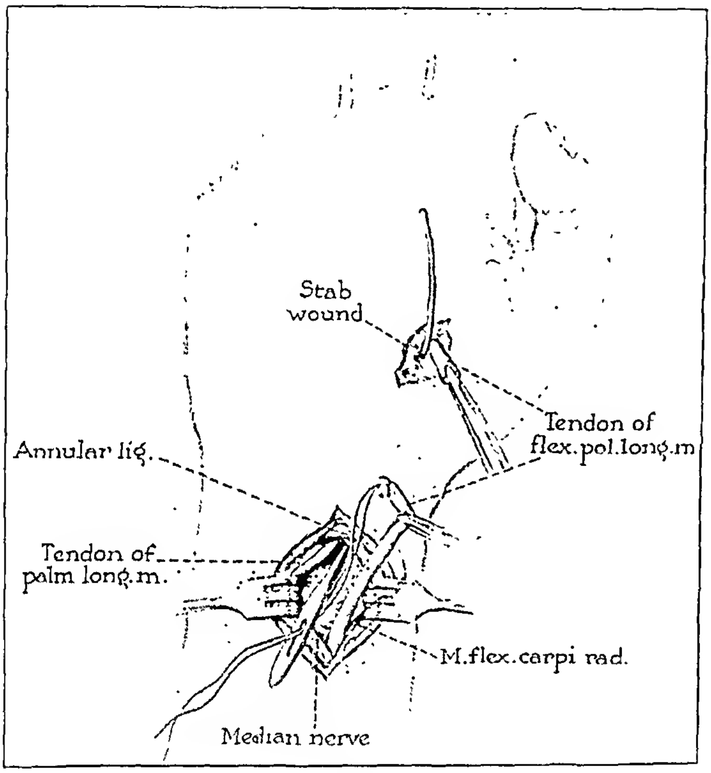

Fig. 1

The author's technique for repair of laceration of the flexor pollicis longus tendon.

The procedure proposed by the writer simplifies considerably the repair of this laceration.

The wound is cleaned with soap and water, as advised by Sumner L. Koch, and then examined. The operation is performed under local anaesthesia. The distal end of the tendon is found usually without extensive dissection. To obtain the proximal end of the tendon, an incision through the skin may be carried up from the wound to above the wrist, but a better procedure is to make a small new incision just above the annular ligament (Fig. 1). Through this new incision, dissection is carried down between the flexor carpi radialis and the palmaris longus tendons to the outer side of the median nerve. Here will be found rather deeply the flexor pollicis longus tendon, and, with a blunt dissector or probe, it may be lifted up without difficulty. Care must be observed here to cause as little damage to the mesotendon as possible. A silk ligature is passed through the end of the tendon, around it, and out through the end, so as not to constrict it. Then a curved blunt probe, with a slot at one end, is passed downward in the compartment which

was occupied by the flexor pollicis longus tendon. This space is very easily found. The silk strands are threaded into the slot in the rear end of the probe and tied. The probe is then passed on through the compartment, drawing the tendon after it and down through the original wound, where it is sutured to its distal severed end. The other structures are approximated, and the wound is closed without drainage.

Postoperatively, the thumb and forearm are immobilized with the thumb in marked flexion, so as to relax most of the traction on the sutured ends of the tendon. Flexion is maintained for three weeks. Then, gradually increasing passive and active movements are permitted. Physiotherapeutic measures may be used to facilitate earlier return of function to the stiffened hand muscles.

CASE REPORT

G. C., a barber, fifty-four years of age, came to the office on October 21, 1934, with a lacerated stab wound on the thenar eminence of the right palm and inability to flex the distal phalanx of the right thumb. On October 20, while turning a faucet, he had pressed rather forcefully on the procelain handle. The handle broke in an oblique direction, and the sharply pointed portion cut deeply into his palm before he could release pressure. Immediately there was rather profuse hemorrhage, which was controlled by pressure. He visited his family physician, who diagnosed a laceration of the tendons and advised operation. The next day he was referred to the writer.

On examination there was an open lacerated wound over the thenar eminence rather near the center of the palm. No infection was present. There was voluntary but painful flexion of the proximal phalanx of the right thumb. Voluntary flexion of the distal phalanx of the thumb was lost. The diagnosis was traumatic laceration and severance of the flexor pollicis longus tendon. The operation described was performed, using 1-per-cent. novocain anaesthesia.

On the twenty-ninth postoperative day, movement with gentle force was allowed and gradually increased. Heat was applied, and the hand was massaged daily. Movement and function were fully restored nine weeks after the accident, when he returned to work.

SUMMARY

1. Trauma to palmar structures from broken faucet handles is a frequent injury.
2. Retraction of the proximal severed end of the flexor pollicis longus tendon occurs to well above the annular ligament.
3. Much tedious dissection is eliminated, and the repair of the tendon is simplified by passing the proximal end under the annular ligament through a new incision.

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FRACTURES OF THE PROXIMAL PHALANX OF THE THUMB

Flexion Treatment

BY S. A. JAHSS, M.D., NEW YORK, N. Y.

In a previous communication,[1] alignment and immobilization of fractures of the proximal phalanges were considered in detail. Those of the thumb were not included, since none were encountered at the time. Whether the author's flexion method would be practical in such cases could only be surmised. Recently such a fracture came under observation.

The history of the case and the physical findings are irrelevant. The roentgenograms (Fig. 1) showed a fracture of the proximal phalanx of the thumb, just distal to the midshaft. Dorsal angulation of the distal fragment was almost 90 degrees. Medial angulation of 15 degrees was also present.

Under general anaesthesia, the partial union in this three-weeks-old fracture was broken up. The proximal fragment was fixed by the thumb and index finger of one hand, and with the same fingers of the other hand the distal fragment was flexed into alignment. When it was thought that reduction was almost accomplished, the proximal fragment was released and the flexion on the distal fragment was con-

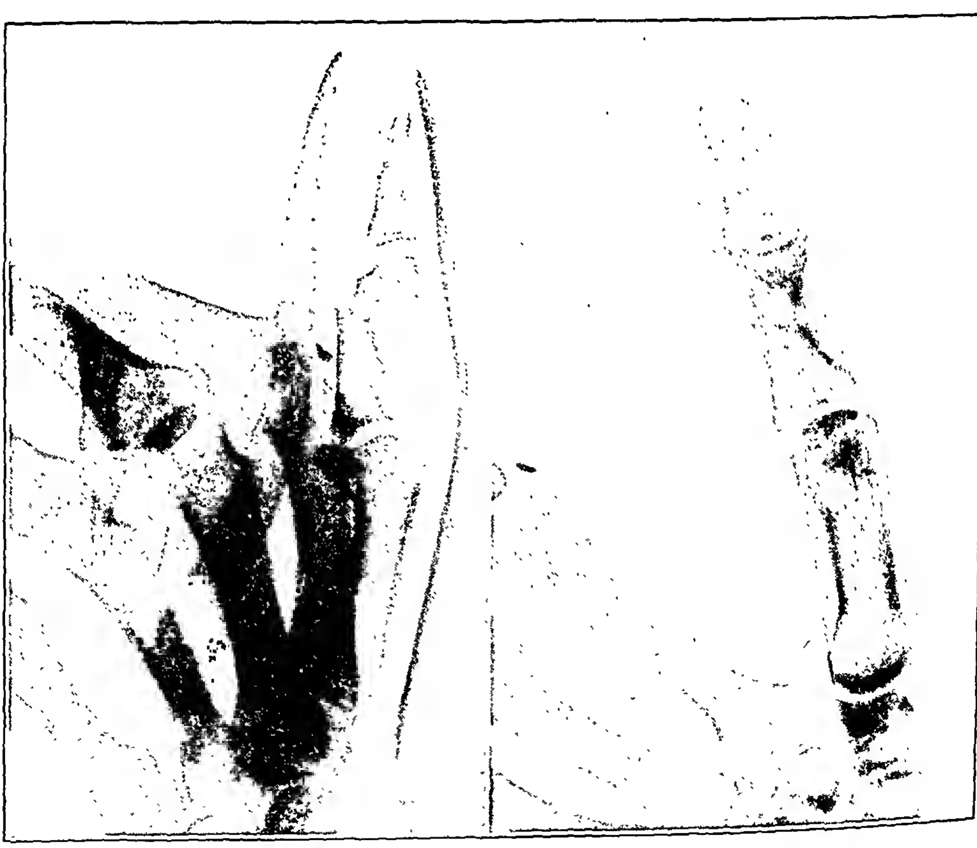

Fig. 1

Fracture of the proximal phalanx of the thumb, showing marked dorsal and mild medial angulation of the fragments.

tinued until the dorsal ligament of the metacarpophalangeal joint was tense. By adducting the thumb the medial aspect of this digit rested against the palm of the hand.

Immobilization in this position was accomplished by means of adhesive plaster strips (Fig. 2).

Roentgenograms taken after reduction (Fig. 3) showed a perfect alignment of the fragments.

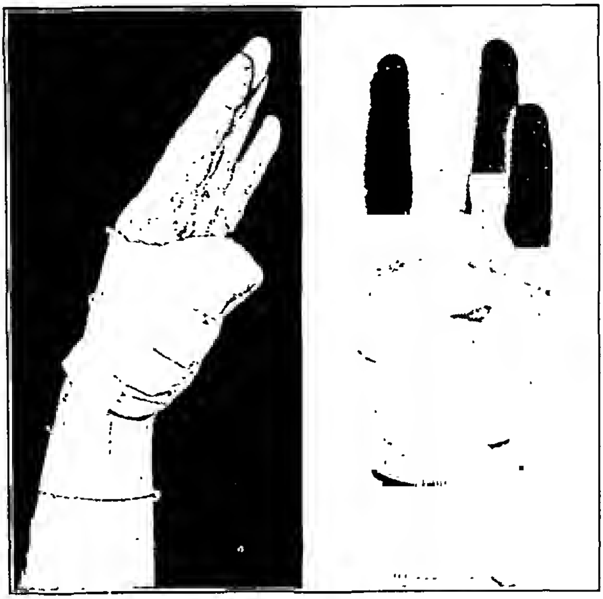

Fig. 2

Immobilization with adhesive plaster strips.

Fig. 3

Perfect alignment of the fragments after reduction and immobilization by the author's method.

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TRAUMATIC DISLOCATION OF HEAD OF FEMUR IN A CHILD

BY CHARLES HAINES, M.D., NEW YORK, N. Y.

Traumatic dislocation of the head of a normal femur out of a normal acetabulum is probably very uncommon among children, for such a lesion is not even mentioned in text-books on fractures and dislocations. Therefore, the writer feels that the following case should be reported.

CASE REPORT

C. P., a white boy, six years of age, fell off a sled while coasting and caught the left foot against a wall in such a manner that the left femur was forcibly abducted beyond a right angle. He immediately felt severe pain in the hip and was unable to walk.

He was seen by the author within an hour after the accident. On examination, the greater trochanter of the left femur was found to be cephalad to the acetabulum. The left lower extremity measured about five centimeters less than the right. It was adducted, internally rotated, and partially flexed at the hip and knee,—the typical position of a dislocated hip.

Roentgenographic examination (Fig. 1) showed complete anterior dislocation of the head of the left femur, but there was normal configuration of the acetabulum and of the head of the femur. There was no fracture.

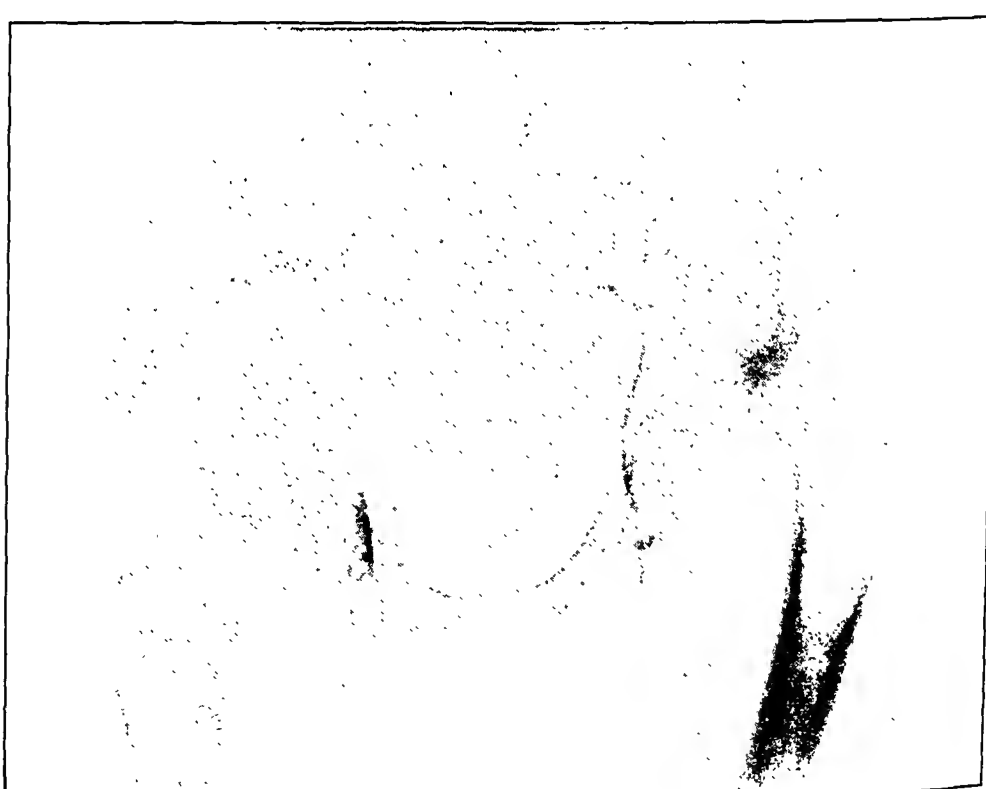

FIG. 1

Anterior dislocation of the head of the left femur.

The dislocation of the head of the femur was reduced by the Simpson method without an anaesthetic. (See Figure 2.) The ankles were held together by a bandage, and the child was put to bed and kept there for approximately five weeks. Convalescence was uneventful.

When last seen, four months after the accident, the child was able to play normally. There was no pain or discomfort in the hip, and all motions of the hip joint were normal. He seemed to have recovered fully from the results of the accident.

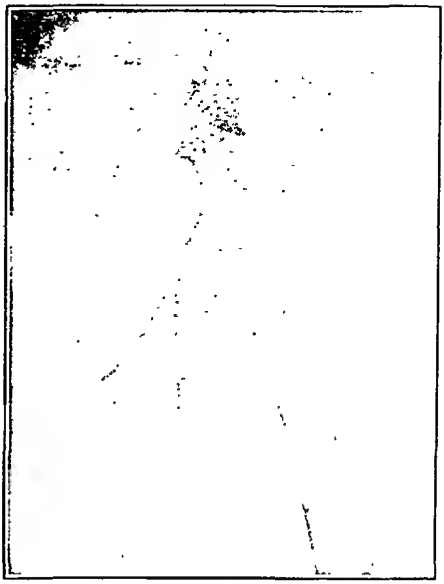

Fig. 2
After reduction.

SUMMARY

In this unusual case of a complete traumatic dislocation of the head of a normal femur from a normal acetabulum in a boy only six years of age, following treatment by the author, the hip had returned to normal four months after the accident.

A LIGHT HYPEREXTENSION BACK BRACE

BY EUGENE L. JEWETT, M.D., ORLANDO, FLORIDA

We are constantly searching for lighter and stronger mechanical means for immobilizing the various parts of the body. Nowhere is this more important than in the case of a fractured vertebral body, where the ambulatory patient must wear the correction cast or brace for many months.

Recently a patient of the author's, seventy-six years old, sustained a compression fracture of the twelfth thoracic vertebral body. She was of the very active energetic type, who would not consent to recumbency on a Bradford frame for long. She was put in a hyperextension bivalved plaster jacket with holes cut out here and there, so as to make it as light as possible. It weighed only approximately four pounds, but in a few days the patient declared that it was unbearable, even though the shoulder straps had been well padded to help distribute the load. She insisted that a brace be obtained for her within a few days, which precluded sending away for any aluminum or celluloid jacket. Having seen the three-point hyperextension back brace, described by Griswold in the July 1936 issue of *The Journal of Bone and Joint Surgery* (*XVIII, 784*), the writer decided to have a similar affair made.

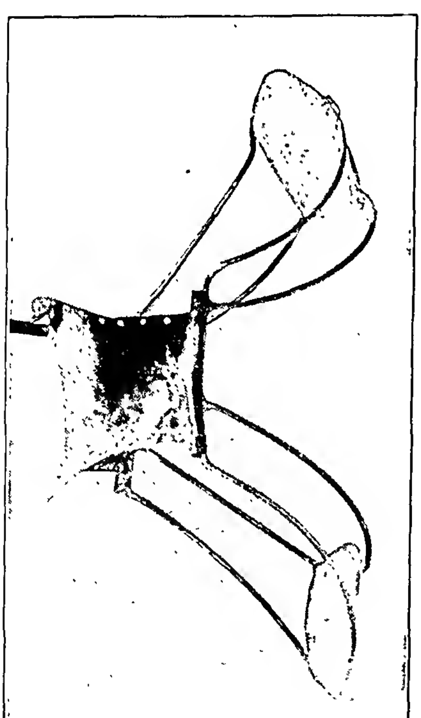

FIG. 1

Lateral view of steel hyperextension brace.

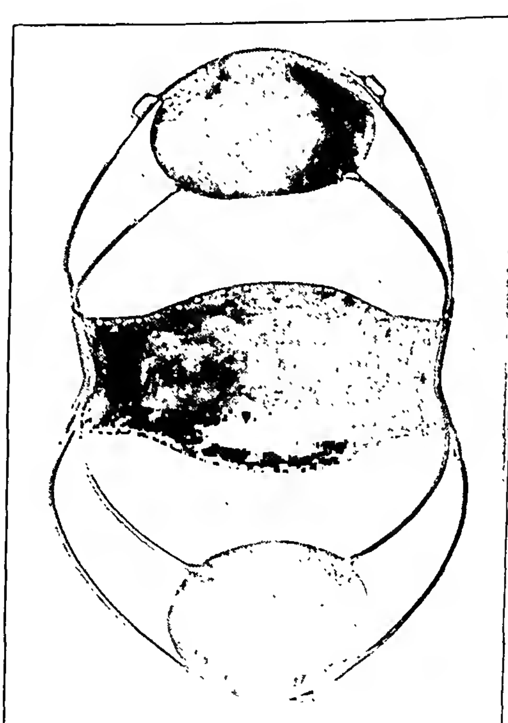

FIG. 2

Posterior view of steel hyperextension brace.

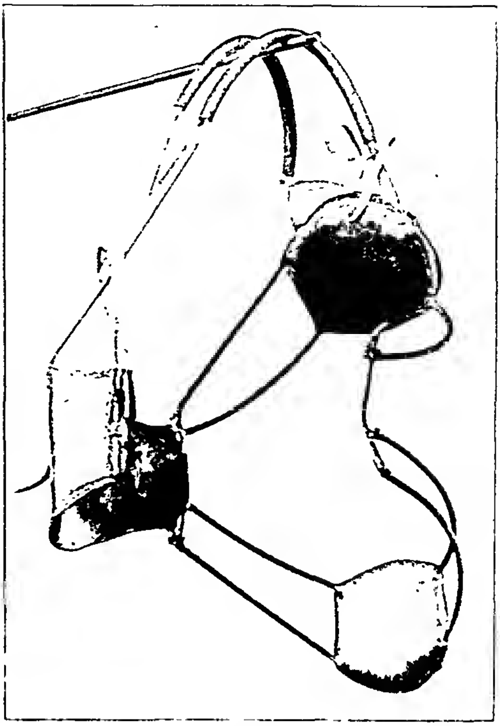

Fig. 3
Lateral view, showing brace opened.

Another plaster-of-Paris jacket was made and in a day and one-half a local welding concern constructed the hinged brace from it. A lead steel was used, which was malleable and could be hammered and bent without too much trouble. It still had enough rigidity to keep the body in the hyperextended position. A minimum of felt and leather was applied, so as to reduce the weight as far as possible. The brace weighs only one and three-quarters pounds without the felt and leather covering and two and one-half pounds when complete. On the back of the brace additional felt strips were placed up and down about one inch apart, so as to take the pressure off the spinous processes. The two parts of the brace were held together by a fixed hinge on one side and a cotter pin lock on the other, which can be easily released. Places were made for shoulder straps, but the patient did not wear them. The author does not see the need for any adjustable parts to the brace by which the hyperextension can be changed. If it is made from a correctly applied plaster-of-Paris jacket, there is no necessity to alter the hyperextension in any way. Of course, Dr. Griswold's brace can be used without having any plaster-of-Paris cast made, and in that respect it is much more adaptable. However, it is the writer's opinion that in most cases it is better to make a brace from a plaster jacket, in order to be sure that all parts fit absolutely correctly.

The brace is taken off every night after the patient is recumbent on the Bradford frame. At first, the writer was doubtful about the advisability of changing so often from the brace to the Bradford frame, but close clinical observation and repeated roentgenograms show a maintenance of hyperextension and freedom from pain.

This patient weighs only about 115 pounds, and, of course, for a heavier person a proportionately stronger brace would have to be built. However, even for a heavy, obese person, the author believes this type of brace would be just as efficient and far more comfortable than the usual hyperextension immobilizing appliances. Of course, the celluloid jacket and the aluminum brace are very light, but they do not permit the same free use of the thoracic and abdominal muscles.

TREATMENT OF FRACTURES OF THE PELVIS

BY HARRY KOSTER, M.D., AND LOUIS P. KASMAN, M.D.,
BROOKLYN, NEW YORK
From the Koster Clinic, Crown Heights Hospital, Brooklyn

The method of treatment employed in fractures of the pelvis depends upon the location and extent of the injuries and the amount and direction of displacement of the fragments. It has long been known that fractures of the iliac fossae without displacement of the fragments after rest in bed for two or three weeks will heal to such an extent that the patient may then become ambulatory. Even in cases with displacement of the iliac fragments healing will also take place readily with or without immobilization by a pelvic sling or circular bandage or cast. Where the fractures involve the pelvic girdle, however, marked displacements must be corrected or serious consequences may result. There are various well-known methods by means of which such displacements may be corrected. In many cases, because the displacement of the outer fragment is in an inward direction, it has been stated that circular compression by sling, bandage, or cast is contra-indicated because it would tend to increase the deformity.

Our experience indicates that all patients who have fractures of any part of the pelvis, including the iliac portions, should also have the support of a pelvic sling, no matter what else is done for them. This support should be given immediately upon admission to the hospital and should be maintained constantly thereafter until healing has progressed to the point where mechanical aids to immobilize the fragments are no longer necessary. If after roentgenographic examination it is found that there are displacements which need correction by traction, the latter may then be applied without interference from the sling.

After an injury sufficiently severe to cause a fracture of the pelvis, the patient suffers considerable pain from the trauma. The sharp edge of this pain would quickly wear off and leave the patient relatively comfortable were it not for the fact that to it are added recurrent traumata resulting from movement of the fragments. These fragments have attached to them on one side the muscles of the abdominal wall and the iliopsoas, and on the other side the gluteus maximus, the small muscles between the girdle and the femur, and the muscles which adduct the latter. Thus, any movement of the body or lower extremity is bound to produce pain by moving the fragments, unless they are supported. Traction on the lower extremity alone does not sufficiently immobilize the fragments to prevent this pain.

The sling, however, insures freedom from this pain by supplying the necessary immobilization. We have devised an apparatus, shown in Figure 1, by which it is possible to maintain constant pressure upon the

fragments and yet allow the patient sufficient freedom of movement for the prevention of bedsores and hypostatic congestion, for easy bowel evacuations, and for the proper hygienic care.

This apparatus consists of a baseboard, four feet long and six inches wide, on which, six inches from each end, are erected two uprights, two and one-half feet long and six inches wide. In a cut-out at each end of the baseboard and of each upright a pulley is fitted. The baseboard is placed under the mattress at the site upon which the buttocks of the patient will rest. The patient is then placed in the dorsal recumbent position on a sling laid on the mattress at that site, to the ends of which are connected cords which cross the median line to the opposite upright pul-

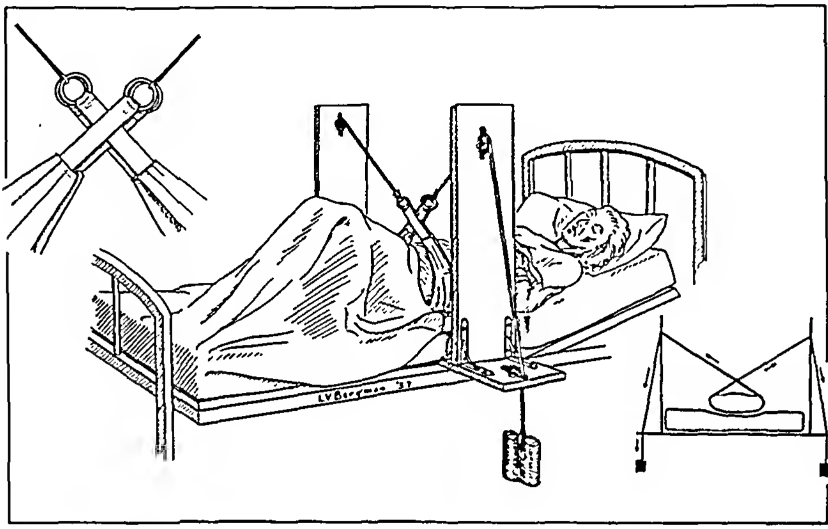

FIG. 1

leys over which they hang. They are prevented from resting against the sides of the bed by the pulleys in the baseboard and they are maintained taut by ten-pound weights swinging freely on the ends.

If the patient's buttocks are raised, the weights sink nearer the floor, but the pull on the sling is not changed. Thus, the patient's hips and body can move or be moved laterally and up off the bed without diminishing the compression of the sling on the pelvis.

In our last fourteen cases, all treated by this method, the freedom from pain of motion has been a striking feature in the clinical course of the fractures. As a result, we feel that the use of the sling should constitute a part of the treatment of all fractures of the pelvis.

A HARNESS FOR USE IN THE TREATMENT OF ACROMIOCLAVICULAR SEPARATION

BY ALLAN H. WARNER, M.D., WOODSIDE, NEW YORK

It has been observed that there is no wholly satisfactory artificial device available for the treatment of acromioclavicular separation. In many cases of this condition, the separation is very slight, and satisfactory repair might be accomplished if the separation were reduced and the parts held in proper apposition. The harness described herein does maintain the shoulder bones in proper relation, and is, therefore, to be considered an important aid in the medical treatment of acromioclavicular separation. It has the added virtue of permitting a high degree of motion at the elbow joint while completely restricting motion at the shoulder.

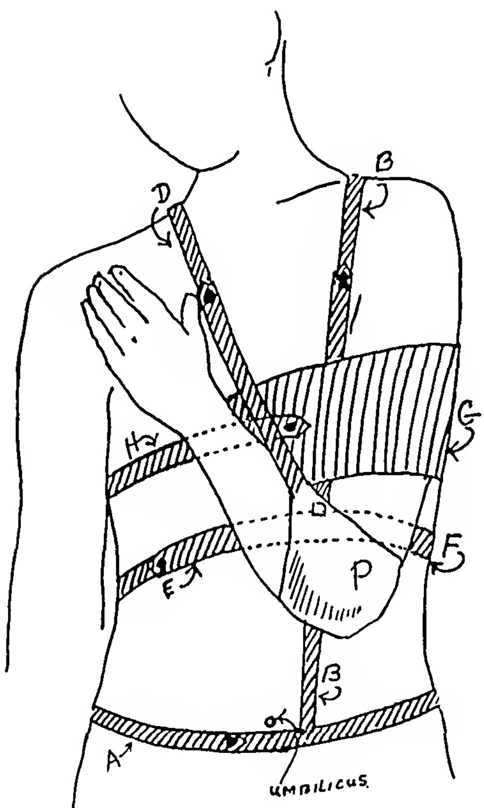

FIG. 1

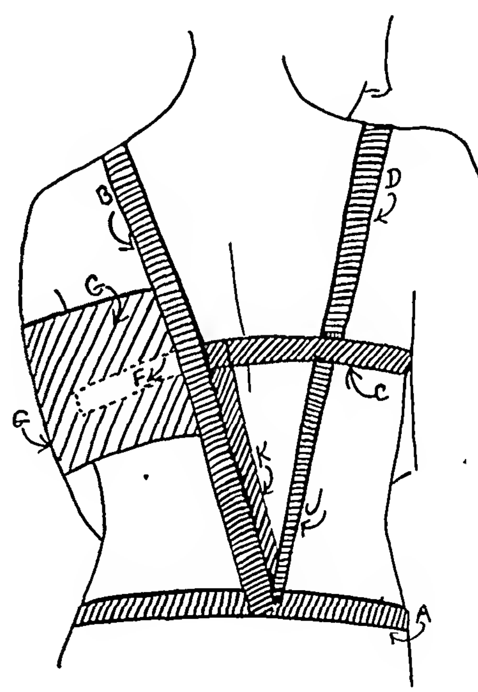

FIG. 2

The apparatus consists of numerous canvas straps, buckles, pads, and a leather pocket. (See Figures 1 and 2.) The present description and illustrations apply to a support for the left shoulder. It is possible to make the apparatus reversible for left or right, and adjustable for variations in stature.

The pocket, *P*, through straps *D* and *B*, pulls the arm upward. The attachment of *B* to the circular straps *EF* and *A* prevents the elbow pocket from sliding toward the midline.

The broad strap *G* pushes the arm onto the anterior surface of the body and holds it there.

Strap *B* depresses the clavicle.

The other straps serve to strengthen the apparatus, and to maintain the key straps in position.

The tip of the acromion and the external extremity of the clavicle have thus been brought into close approximation with one another. This has been accomplished as follows:

1. There is an upward pull on the flexed forearm and elbow, the humerus being held more or less parallel to the vertical axis of the body. The upward pull is thereby transmitted to the shoulder and to the acromion.

2. The arm, always parallel to the vertical axis of the body, is rolled forward as far as it will go, which will bring it to about the anterior axillary line. This carries the acromion medially closer to the clavicle.

3. The clavicle is pressed downward, bringing its outer extremity closer to the acromion.

The patient on whom the device was originally used was employed as a machine feeder. While wearing the harness, he was able to continue to do the work which required a rather sweeping circular motion with the affected limb. Numerous other devices had been tried on this patient. All adhesive tape and bandage combinations had to be discarded because they were too irritating to his skin. Our device he kept in place day and night, with only brief intervals to permit bathing. Eight weeks after the initial trauma, the patient was permitted to discard the girdle completely because it was found that a perfect anatomical result had been obtained. There was some beginning atrophy of the neighboring muscles and limitation of abduction of the humerus to about 75 degrees. These defects are being treated.

PORTABLE EXTREMITY TRACTION FOR CHILDREN * †

BY HENRY MILCH, M.D., F.A.C.S., NEW YORK, N. Y.

Associate Attending Orthopaedic Surgeon, Hospital for Joint Diseases

The application and maintenance of efficient traction in children frequently presents such difficulties as to necessitate hospital care. During a recent quarantine of our pediatric wards, this problem arose at a time when hospitalization was impossible. To continue with the necessary treatment, we were forced to adopt the principle of the banjo splint. Considering the trunk as the hand, and the extremities as the fingers, to which traction was to be applied, we devised a trunk banjo splint and a modified splint, which gave complete satisfaction.

In two cases in which this method was used, a slightly different application of the fundamental principle was made in each case. The first was a case of pneumococcal synovitis of the hip, in which the typical banjo splint was used. The second was a case of fracture of the shaft of the right femur, in which overhead traction was accomplished by means of a slight modification.

The apparatus is extremely simple to apply and consists of a plaster-of-Paris trunk piece in which an iron bar for traction is incorporated. The chest, shoulders, and iliac

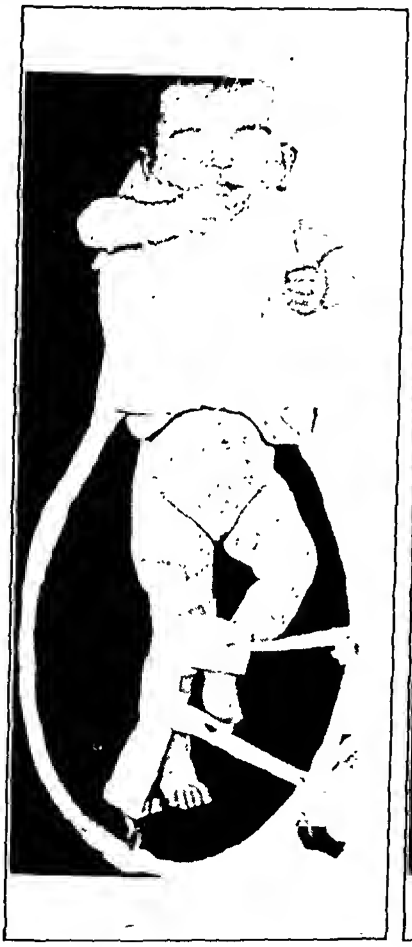

FIG. 1-A

FIG. 1-B

Fig. 1-A: Shows the banjo type of splint, the body plaster, and the incorporated iron rod, with the traction strips and the rotation tabs.

Fig. 1-B: Lateral view of the banjo splint applied in a case of pneumococcal infection of the hip joint.

* From the Service of Harry Finkelstein, M.D.

† Presented before the Orthopaedic Conference at the Hospital for Joint Diseases on April 20, 1937.

FIG. 2-A

FIG. 2-B

The modified traction splint for fracture of the femur.

crests are meticulously protected against the likelihood of pressure sores by the careful insertion of felt padding. A typical plaster-of-Paris bandage, with shoulder straps, is applied to the trunk and is carefully molded around the iliac crests. When the plaster has properly set, a sufficiently large piece of half round, cold rolled iron, one-eighth by one-half of an inch, is bent into appropriate shape (Figs. 1-A, 1-B, 2-A, and 2-B) and is covered with a plaster-of-Paris bandage. Adhesive stickers are applied to the extremity, and a wooden spreader is inserted. Elastic traction, either by rubber bands or by rubber tubing, is then applied. By means of adhesive tabs applied to the stickers and carried across to the opposite side, internal or external rotation may be accomplished.

FIG. 3

Roentgenogram showing the reduction obtained by means of the traction splint.

The principle of combining body and leg traction in a portable splint is not new. Cabot's posterior wire splint, especially as modified by Flint to allow traction, affords an excellent example of this method of treatment. However, it is felt that the use of a plaster bandage which encircles the

trunk is apt to give more stability to the traction than can be obtained by simple adhesive bandaging.

The method may be adapted to provide traction to the lower as well as to the upper extremities. In fracture of both femora, the iron banjo splint, instead of the bayonet-shaped splint, may be used. The apparatus allows correction of adduction, abduction, flexion, or extension deformities. It permits easy nursing and surgical approach to the whole of the lower extremity. Because of the fact that the plaster does not extend below the iliac crests, soiling seldom occurs. The necessity for prolonged or costly hospitalization is minimized.

A PORTABLE FRAME FOR THE SUSPENSION OF FRACTURES OF THE FEMUR IN CHILDREN *

BY GEORGE W. HAWLEY, M.D., F.A.C.S., BRIDGEPORT, CONNECTICUT

From the Orthopaedic and Fracture Service of the Bridgeport Hospital

The device shown in Figures 1, 2, and 3, designed by the author, has been in use at the Bridgeport Hospital for several years and has proved very satisfactory. It makes the patient portable and the stay in the hospital short. This is of benefit to the child, the parents, and the hospital. Children are anxious to go home and parents are glad to take them home. At the same time the hospital benefits by renting the apparatus which soon pays for itself.

The construction of this frame is simple. It can be made in the workshop of a general hospital. The frame has a spring bottom like a child's crib. The height of the overhead bar can be adjusted to the length of the leg. Traction can be increased by raising the bar, or by shortening the traction straps.

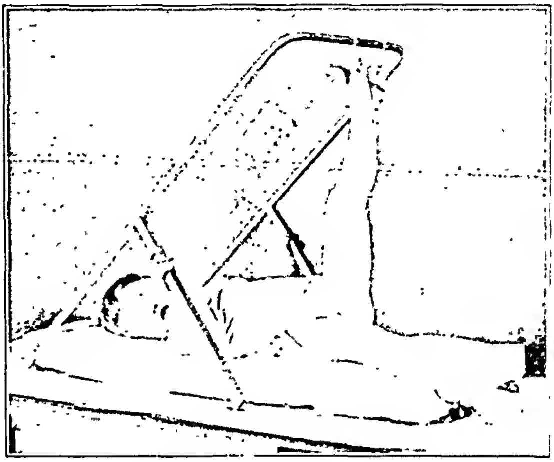

Fig. 1

Showing patient with a fracture of the shaft of the femur in the frame, with the leg in overhead suspension. The pelvis is raised for gravity traction. The leg is exposed for roentgenographic examination. The patient and the frame are one unit and are portable.

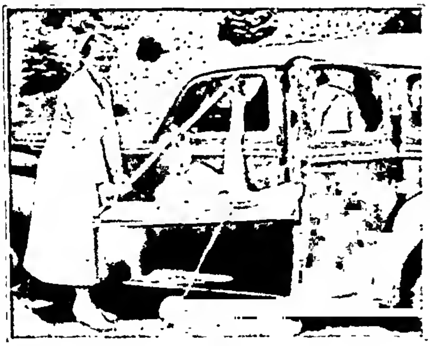

Fig. 2

Patient on his way home.

Fig. 3

Patient on lawn at home a few days after leaving the hospital, having "fun with a fracture".

* The patient in the fracture frame was shown at the Clinical Session of the Meeting of the Connecticut State Medical Society held in Bridgeport, May 19 and 20, 1937.

AVULSION FRACTURE OF THE ISCHIAL TUBEROSITY

BY HAROLD H. COHEN, M.D., NEW YORK, N. Y.

*From the Hospital for Joint Diseases *, New York City*

A careful search of the literature has revealed only three cases of avulsion fracture of the ischial tuberosity.

The first case was reported by an Englishman, J. M. Berry, in 1912. The patient, twenty-three years old, sustained the injury while running and, because of persistent pain and disability three years afterward, the displaced tuberosity was removed.

The next case was recorded in the United States by Milch in 1926. This patient was a girl, eleven years old, who, while attempting to regain the upright position from the sitting "split" position, experienced a sudden sharp pain in the right buttock and fell back. In this case, not only was the ischial tuberosity avulsed, but the entire right side of the pelvis was displaced downward. Here, apparently, the sheering stress was such as to tear the ligaments binding the symphysis pubis and the sacro-iliac joint.

The most recent case was reported in Germany in 1933 by Hellmer. His patient was seventeen years old and an athlete. The injury occurred while running 400 meters. Open operation was immediately performed, and the avulsed tuberosity was replaced and held in position by several chromic catgut sutures passed through the obturator foramen. Bony union was noted at the end of four months, and the patient was allowed to compete in athletics one month later.

Because of the rarity of this fracture, the author wishes to place on record the following case.

A colored boy, sixteen years old, was first seen in the Out-Patient Department of the Hospital for Joint Diseases in November 1936. He complained of pain in the left buttock and inability to take long steps with the left leg. The history was as follows: While playing football, he had caught the left foot in a hole in the ground, had crossed the right foot over the left, and, in attempting to swing the left leg forward, had experienced a sudden sharp pain in the left buttock. He had fallen to the ground and had been brought home, where he had remained in bed for one week. He then decided to come to the Hospital.

Examination revealed a well-developed, rather tall, colored boy who did not appear to be in any pain, but who walked with a definite left limp. There was a reduced left stride. When sitting on a hard chair, he complained of pain in the left buttock. When an attempt was made to passively extend the flexed knee while the patient was seated, he complained of pain in the left buttock. Left straight-leg raising was present to 145 degrees. No tenderness could be elicited over the ischial tuberosity, and rectal examination was negative for any mass or tenderness. Measurements of both extremities for real or apparent shortening did not disclose anything significant.

Roentgenographic examination of the pelvis was ordered, and the following report

* Service of Leo Mayer, M.D.

was returned: "Examination of the pelvis and of the left hip joint discloses a soft-tissue calcification about the size of a pecan situated near the left ischial bone. The contours of the ischium show irregular erosion. In view of the history of trauma, the soft-tissue shadow represents an avulsed ischial epiphysis." (See Figure 1.)

The patient was kept at rest for three weeks and discharged for follow-up care in the Out-Patient Department. He was next seen on December 5, 1936, and the following note was made: "Patient states that he has played football and feels very well. Examination reveals that there is still some weakness of the flexors of the left knee." The patient was again seen on March 15, 1937, and examination at this time revealed a complete return of hamstring power. A follow-up roentgenogram (Fig. 2) was taken on May 7, 1937, and the report was as follows: "Examination of the pelvis reveals the previously described avulsion fracture of the ischial tuberosity. There is beginning bony union."

Fig. 1

November 10, 1936, roentgenogram showing avulsion of the ischial epiphysis.

Fig. 2

May 7, 1937, roentgenogram showing beginning bony union.

In the differential diagnosis the only possible source of error is confusion with an ossifying hematoma. The location of the lesion, its crescentic appearance, the erosion of the ischium, the manner of production, and its occurrence in an individual of the epiphyseal age should make the diagnosis certain. In summation, the following points are to be noted:

1. Avulsion fracture of the ischial tuberosity, though uncommon, should always be suspected up to the age of twenty-five when union generally occurs.

2. Bony union is not necessary for a resumption of normal activities.

3. This fracture occurs in one of two ways, or in a combination of both,—a sudden forceful pull on the ischial tuberosity while the pelvis is fixed in flexion, or a sudden flexion of the pelvis with the lower extremity fixed and the knee in complete extension.

4. The treatment of choice is conservative,—namely, complete rest in bed with the knee in flexion if much hamstring spasm exists.

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News Notes

The Congress of the **Jugoslavian and Czechoslovakian Orthopaedic Societies** will be held in Belgrade on October 17 and 18. The principal topic for discussion will be Congenital Dislocation of the Hip. The conservative treatment will be presented by Dr. D. Yovtchitch who is President of the Congress, and operative treatment will be discussed by Prof. Zahradníček, of Prague, President of the Czechoslovakian Society.

The Fifteenth Annual Meeting of the **Academy of Physical Medicine** will be held at the Hotel Walton, Philadelphia, October 19, 20, and 21. Further information may be obtained from the Chairman of the Program Committee, Dr. William D. McFee, 41 Bay State Road, Boston, Massachusetts.

The Pan American Medical Association has announced its Seventh Cruise Congress to Havana and the West Indies. The S.S. "Queen of Bermuda", chartered for the Cruise, will sail from New York January 15, 1938. Applications should be sent to the Pan American Medical Association, 745 Fifth Avenue, New York, N. Y.

The Second Congress of the **Brazilian Association of Orthopaedic Surgery and Traumatology** was held in Rio de Janeiro, Brazil, July 1–4, under the direction of Dr. Achilles Araujo, President. Dr. Fred H. Albee of New York, Honorary President, was the guest speaker. An interesting program was presented and the Congress was well attended.

The annual meeting of the **Advisory Board for Medical Specialties**, which is the coordinating Board of the twelve certifying boards in the various specialties, the Association of Medical Colleges, the American Hospital Association, the Federation of State Medical Boards of the United States, and the National Board of Medical Examiners, was held at Atlantic City, New Jersey, on June 6, 1937.

The following officers were elected:

President: Willard C. Rappleye, M.D., New York, N. Y.
Vice-President: W. P. Wherry, M.D., Omaha, Nebraska
Secretary-Treasurer: Paul Titus, M.D., Pittsburgh, Pennsylvania
Executive Committee: The Officers and
W. B. Lancaster, M.D., Boston, Massachusetts
R. C. Buerki, M.D., Madison, Wisconsin

Dr. Louis B. Wilson of Rochester, Minnesota, the retiring President of the Board, was elected an emeritus member of the Board.

The American Academy of Orthopaedic Surgeons will hold its Sixth Annual Convention in Los Angeles, California, January 15–19, inclusive. The headquarters will be at the Biltmore Hotel situated in the downtown district of Los Angeles.

The Program Committee have assembled an interesting and diversified group of papers. There will be a symposium on the subject of non-union and bone-graft surgery. There will also be a symposium on fractures of the spine. The tentative program includes a wealth of interesting material presented by the ablest orthopaedic surgeons of America.

The local committee have made arrangements for the entertainment which will prove to be of interest to all. The annual golf tournament will be held; there will be visits to the motion picture studios and other features of interest about Los Angeles.

The Association of Military Surgeons will hold its convention at the Ambassador Hotel, Los Angeles, California, October 14–16.

The Twenty-Seventh Annual Clinical Congress of the **American College of Surgeons** will be held in Chicago from October 25 to 29. The headquarters will be at the Stevens Hotel. A committee of Chicago surgeons headed by Dr. Vernon C. David, Chairman, and Dr. Michael L. Mason, Secretary, is in charge of local arrangements. Further information may be obtained from Mr. A. D. Ballou, General Manager of the Congress, 40 East Erie Street, Chicago, Illinois.

BRITISH ORTHOPAEDIC ASSOCIATION

The British Orthopaedic Association, under the Presidency of Mr. W. R. Bristow, held its Spring Meeting from May 17 to 21 in Copenhagen and Stockholm. The party consisted of some sixty members and their guests.

Copenhagen

Three days were spent in Copenhagen, of which two were devoted to visiting the new Orthopaedic Hospital on the outskirts of the city. An attractive program was arranged by Dr. Paul Guildal and his colleagues and consisted of operative demonstrations and presentations of short papers.

Dr. Guildal gave an account of the functions of the Danish Orthopaedic Hospital, outlining the origin and progress of the treatment of the crippled child in Denmark. The whole service in Copenhagen is financed by the State and the medical staff are all salaried officials. In a second paper Dr. Guildal gave an interesting résumé of the principles and results of the orthopaedic treatment of infantile paralysis. His practice and results corresponded closely with British views on this subject.

Dr. Bentzon advocated the use of drilling osteoclasis in preference to osteotomy for the correction chiefly of outward curvature of the tibiae due to rickets. Through a tiny incision, multiple drill holes are made in a transverse line at the apex of the deformity. The bone is then broken manually or with an osteoclast.

Dr. Bentzon also demonstrated the result of an operation for gluteus-medius palsy. The procedure consists of transferring the insertion of the upper two-thirds of the gluteus maximus upward and forward to occupy a true lateral position on the crest of the ilium. An excellent result had been obtained in the patient whom he showed, for the patient walked without a trace of limp and could stand on the affected leg with perfect balance.

Dr. Kiaer made some remarks on the treatment of joint contractures. He had found very helpful a combination of infiltration of the capsule of the affected joint with local anaesthesia and active mobilization. He suggested that similar methods could be employed usefully in the treatment of recent sprains and of painful scars. He also showed two patients after treatment for sciatic scoliosis. He commented on the difficulties of establishing any cause for the condition, and stated that he had found that immobilization of the lumbosacral spine in a plaster-of-Paris jacket, applied with the patient suspended or bending forward, gave the most satisfactory results.

Dr. Staermose gave a brief review of calcaneonavicular fusion. Although in many people this condition represents no more than a symptomless anatomical anomaly, yet it is occasionally found in association with spasmodic flat-foot. Excision of the bridge between the two bones and the interposition of part of the muscle belly of the extensor digitorum brevis usually results in cure of the peroneal spasm.

Dr. Foged showed many results of operations for torticollis. He found that the most universally satisfactory procedure had been open division of both heads of the sternomastoid just above the clavicle, followed by a long period of daily stretching and reeducation.

Dr. Chievitz gave an account of the geographical distribution of tuberculosis among the Danish population and discussed the relationship between human and bovine types

in surgical lesions. The majority of these were due to the bovine type. A brief symposium on osteo-arthritis of the hip followed:

Dr. Morville dealt in a clear, concise way with the classification of this disease from the clinical and roentgenological standpoints.

Dr. Berntsen described his method of drilling ("*forage*") the femoral neck and head, the procedure described originally by Graber-Duvernay. It was interesting to hear that very considerable relief of pain had followed this simple operation in over 60 per cent. of his series of patients suffering from osteo-arthritis of the hip.

Dr. Therkelsen discussed in great detail the indications for and the results of "shelf" operations performed in adult life for congenital subluxations of the hip. In contrast with the experience of British surgeons, Dr. Therkelsen had found the operation satisfactory in relieving pain and in increasing stability of the hip.

The British Orthopaedic Association dinner was held at the Restaurant Nimb and the guests included the Danish contingent.

Stackholm

In this city two mornings were spent at the new *Karalinska Institutets Orthopedista Klinik Vanföreanstalten* where Prof. Waldenström and his colleagues and assistants presented a most stimulating program.

Prof. Waldenström showed the results which he had obtained from arthroplasties on various joints. Concerning arthroplasties in general, Prof. Waldenström stated that the difficulty lies not only in carrying out the operation skilfully, but also in deciding which cases are suitable for operation. The patients are kept in the hospital for some time before making a decision, not only for the purposes of physical examination, but also, which is still more important, to get an impression of their mentality and their reaction. The postoperative treatment is painful, and the patient must not only submit to passive movements, but he must also carry out energetic active ones many times each day in spite of pain.

Prof. Waldenström also presented some of his views on certain hip conditions of which he has made a life-long study. These include coxa plana (pseudocoxalgia) and coxa magna-valga-luxans. He attributes the latter to a mild local inflammatory process, possibly tuberculous in some patients, which results in overgrowth of the femoral head, so that it is no longer contained completely within the acetabulum. The relationship between osteo-arthritis and the congenital and youthfully acquired deformations of the femoral head were discussed.

Prof. Waldenström also performed an operation for recurrent dislocation of the shoulder,—the insertion of an autogenous bone graft into a niche along the anterior margin of the glenoid (Eden-Hybbinette operation).

Dr. Friberg read a paper on spondylolisthesis. If symptoms are present, he advocates fusion of the slipping vertebral body to the spinal segment immediately distal to it, through an abdominal transperitoneal approach. Dr. Friberg performed his own modification of this operation on a patient during the course of the meeting.

Dr. Knutsson gave a brief but detailed account of the roentgenographic findings in sacralization of the fifth lumbar vertebra. He emphasized the fact that symptoms could arise not only from arthritis in the joint between the sacralized transverse process and the sacrum, but also from arthritis in the smaller intervertebral joints of the lower lumbar segments.

Dr. Silfverskiöld described the condition known as chondromalacia patellae and its treatment. He regards it as the most common form of internal derangement of the knee and believes that the cartilage of the patella is the first in the body to undergo degenerative changes. The clinical picture consists of crepitations between the patella and femur on movement, associated with attacks of pain and swelling and peripatellar tenderness. For mild lesions he advises conservative measures and for more advanced cases, excision of the damaged cartilage in part, or in whole, covering the raw area with a free fascial

graft. About seventy patients have been operated on and the majority have perfect function. Some of them were demonstrated.

Dr. Nilsonne gave an account of the results of the operative treatment of infantile or congenital coxa vara and presented some patients. He has performed a wedge osteotomy in the trochanteric region on sixty patients suffering from this condition. His best results have been obtained in those patients on whom the osteotomy was done between the ages of six and eight. In these circumstances successive roentgenograms showed that the femoral neck had reconstructed itself over a number of years until eventually the hip could not be distinguished from the normal either by clinical or roentgenographic examination.

Miss Hojer, Director of the Cripples Educational and Training Establishment, gave a most clear account of the arrangements in Sweden for the rehabilitation of the cripple and for his engagement in a lucrative occupation. The whole scheme, which embraces workshops, boarding schools, and salaried social workers, is subsidized by the State Grants up to about half of the total expense.

Other short papers were read on the syndrome of the scalenus anticus and cervical rib by Dr. Wiberg, on congenital ulnar deviation of the fingers, by Dr. Lundblom, and on the results of the shelf operation for congenital subluxation of the hip in adults by Dr. Severin.

The British Orthopaedic Association dinner was held at the Hasselbacken restaurant. The local orthopaedic contingent and several other distinguished members of the Stockholm medical profession, including Prof. Key, were guests.

Social entertainment for the visitors and their guests was well organized and included tours to all the places of interest, and these are many, in and around Stockholm. The weather was perfect and everyone was unstinting in praise for this beautiful city. No one who participated is likely ever to forget the experience of dining as the guests of Prof. and Mrs. Waldenström at Hoganloft, Skansen, amid the charming setting of an ancient Swedish house with old folk dances on the lawn lighted only by flaming log fires.

At a recent meeting of the Executive Committee, the following were elected to Associate Membership in the **British Orthopaedic Association:**

Mr. C. Lee-Pattison, King Edward VII Hospital, Rivelin Valley Road, Sheffield 6, England

Mr. R. C. Murray, The Royal Infirmary, Liverpool 3, England

Mr. A. M. Rennie, Wester, Furtray, Kintore, Aberdeenshire, Scotland

Mr. F. H. Aitken Walker, 16 Westcote Road, Reading, Berks., England.

Correction

Dr. Emanuel B. Kaplan of New York has requested that we publish a correction in his article entitled "Extension Deformities of the Proximal Interphalangeal Joints of the Fingers" published in *The Journal* for July 1936. The fifth line of the first full paragraph on page 783 should read "the bifurcation of the sublimis tendon were cut across the joint".

Current Literature

Traité de chirurgie orthopédique. L. Ombrédanne et P. Mathieu. (En 5 Volumes.) Paris, Masson et C[ie], 1937. Chaque tome, 300 francs; les 5 volumes, 1500 francs.

Volumes III, IV, and V of the series (a review of Volumes I and II appeared in *The Journal* for July 1937) complete this very comprehensive treatise which has considered practically all of the conditions of interest to the orthopaedic surgeon and to the traumatologist, as well as to a large number of surgeons and medical men who are thrown in contact with these conditions.

The third volume begins with a chapter on tumors of the spine, both secondary and primary, the majority of which are considered malignant, also the parasitic tumors. With this chapter ends the portion of the series which deals with the region of the spine. The remainder of the volume is given to the upper extremity,—the scapular girdle, the scapula (with some affections of the thorax), the shoulder, the upper arm, the elbow, the lower arm, the wrist, and the hand. The affections and the traumata which occur in each region are considered, especially the fractures and dislocations with fractures involving the joints, as well as the derangements of the joints. The diagnosis, including the roentgenographic interpretation, and the conservative and operative treatment have been thoroughly considered. The discussion of the joints includes many of the tuberculous affections, but emphasis is given to the traumatic conditions. To the affections involving the wrist, and especially the hand, a much larger space is accorded than is usual in this form of treatise, and the consideration of many of the smaller difficulties, such as trigger-finger, adds to the practical value.

The fourth volume takes up the pelvic girdle and discusses the anomalies, fractures, and dislocations, with a consideration of the mortality which occurs in these severe traumatic conditions. The infectious lesions of this region (osteomyelitis and tuberculosis) are presented with a discussion of the pathology, clinical course, prognosis, and treatment. This is particularly helpful because of the severe complications, difficult to treat, which are met with in this group. The affections of the hip, including the congenital conditions and the dystrophies, also the traumatic and infectious lesions, are treated in the same manner. Fractures of the thigh are also given a place. A discussion of the affections of the knee completes the volume. Here, as in the rest of the work, emphasis is placed on the traumatic sequelae and the conditions requiring active and operative treatment, but the lesser conditions and the conservative treatment are not neglected.

Volume V is occupied with a consideration of some of the affections of the leg which are not covered in Volume IV, and with a discussion of roentgenograms of young and developing bone and of congenital pseudarthrosis, including fractures of the lower leg. The affections of the foot and the tibio-astragalar joint, including both congenital and acquired deformities and fractures, occupy a large part of the volume. The etiology and the roentgenographic determination of these deformities are considered, followed by the discussion of the treatment, in which both conservative and operative methods are evaluated. The operative treatment seems to be more favored, but this is a part of the modern trend in medicine and surgery. In the last portion of the fifth volume, the technique of amputations and directions with regard to protheses are given, followed by a discussion of the paralyses of the upper and lower extremities with a consideration of the treatment, both conservative and operative.

The authors state that in these five volumes the effort has been made to avoid the common error of presenting too much of personal opinion, and to this end they have obtained the collaboration of a large number of surgeons of extensive experience. It is recognized that in the present state of knowledge no one can possess the best in each

department, even in his own specialty, therefore the work has been distributed among a large number of contributors, each of whom has been chosen with reference to his particular experience with the special subject which has been assigned to him. Also, a very complete bibliography for each subject is added, to render a more complete representation of the present status of each. Each contributor has given full recognition to the advances which have been made by workers in other countries. At the same time, these collaborators have presented the present status of the advance of knowledge which has resulted from the work of those in their own country, hoping that by this many outside their borders may recognize what has been accomplished by the French orthopaedic surgeons.

Throughout the books the authors' opinions and experiences are evident, and this adds to the interest as well as to the value of the presentation of the different subjects. The books are profusely illustrated with excellent roentgenograms, and, according to the prevailing custom, line drawings are used to clarify the interpretation of many of these roentgenograms. The different stages of the operations are also shown by excellent drawings. These five interesting volumes constitute a very valuable series.

ROSE & CARLESS MANUAL OF SURGERY. Edited by William T. Coughlin, M.D. American (Fifteenth) Edition. Baltimore, William Wood & Company, 1937. $9.00.

Dedicated to Lord Lister, under whom Carless, one of the original writers, worked, this book now appears in its fifteenth edition. It was first published in 1898 and has been translated into the Hungarian, Chinese, and Arabic languages. This American edition has been arranged from the new English edition prepared by Cecil P. G. Wakeley and John B. Hunter, and certain sections relating to the specialties have been omitted. Many chapters have been completely rewritten,—considerable new material has been added and obsolete matter has been eliminated. New chapters appear on "Surgical Shock" and "Surgery of the Central Nervous System".

The text is printed on excellent paper. The titles and subtitles, such as "Treatment" and "Etiology", appear in bold-face print, making it easy to pick out the desired sections readily. There are many full-page colored drawings which, together with the photographs interspersed with the text, are clear and very interesting.

The arrangement of the subject matter by chapters is well done. The first chapters deal with infections, inflammation and repair, the blood, pyogenic infections and infected wounds, ulceration, necrosis and gangrene, and specific infections. Then appears a fairly good outline of tumors and cysts and their treatment. The chapter on "The Use of Physical Agencies in Surgery" is interesting and is usually lacking in surgical treatises. The discussion of radium is especially well written and well illustrated.

Fifty pages are devoted to deformities and orthopaedic surgery and twice as many pages to fractures. The latter section is probably the best in the book. The pathology of fractures, the mechanism of occurrence, and the methods of treatment are thoroughly discussed and well illustrated. The use of fascia in the repair of fractures of the patella and of the olecranon is not included. No mention is made of the use of antitetanic serum or gas-gangrene vaccine in the section on compound fractures, although a full discussion of these drugs appears in the section on infected wounds. The statement is made that Lane plates are now but rarely used. One objection to their use is that "absolute fixity of the fragments without the possibility of the slightest movement does not conduce to rapid or effective healing; the best results are secured when it is possible for the ends to rub one against the other without displacement". These statements might be refuted by some American surgeons.

In the section on cancer of the breast there are excellent drawings showing the proper way to palpate the breast and the axilla. The text points out the need of radical removal of the breast, but the accompanying illustration shows a circular incision which does not even remove the whole breast.

The statement is made that cancer of the lip is commonly due to irritation produced

by smoking a short clay pipe. That feeling is not held in this country where the clay pipe has practically disappeared, and where cigarette smokers have displaced the pipe smokers, but without eliminating the cancers of the lip.

This is an excellent treatise on surgery. The present edition is far ahead of the previous ones, all of which have been good. It is thoroughly up to date, as all of the latest subjects have been considered.

Die Anatomie der angeborenen Hüftverrenkung (The Anatomy of Congenital Dislocation of the Hip). Prof. Dr. V. Putti. Stuttgart, Ferdinand Enke, 1937. 82 marks.

This is a translation by Prof. Dr. G. A. Wollenberg and Dr. H. Wolff of the work by Prof. Putti published in Italian.

A book by Prof. Putti on the subject of congenital dislocation of the hip needs no comment except one of congratulation to the medical public on the privilege of possessing such a volume. The result of Prof. Putti's studies and experience with this affection is always welcome, and this edition is no exception. In an elaborate volume of full folio size, with twenty pages of text and seventy-seven pages of illustrations, Prof. Putti has presented by a "rivulet of text and a meadow of illustrations" the information which should lead his readers to a most complete understanding of this subject.

He stresses the need of familiarity with the normal anatomy and the variations from the normal in these cases, and he includes a careful description of the normal anatomy of this whole region and a discussion of its bearing on that found in congenital dislocation, together with the abnormal anatomy and the varied malrelations and abnormal structures which are found in these cases. Each part of the joint is described with the special object of defining its importance in the formation of the deformity and its influence in obtaining reduction and retention, so that it may be given sufficient recognition in the treatment.

As a rule, it is not possible to study in detail these features of this deformity, but Prof. Putti has taken advantage of exceptional opportunities which have come to him. In the cases in which reduction has been performed, the anatomy of each structure with its relation to the joint is shown. Many of the illustrations are photographs of dissections in cases which have been operated upon, and they show the actual conditions which exist. These add very definitely to the understanding of this condition and serve as guides to the operator. Roentgenograms, accompanied by line drawings, demonstrate the form and relation of the parts of the joint both before and after operation, as well as the large variety of the types of dislocation. There are also portrayed the sequelae from the deformity of the head which are so often found several years after reduction. Unusual illustrations in color show the different steps of the operation of open reduction.

It is seldom that one finds a subject treated so thoroughly and accurately and presented in such an excellent manner.

Injuries and Diseases of the Hip. Surgery and Conservative Treatment. Fred H. Albee, M.D., LL.D., F.A.C.S. Assisted by Robert L. Preston, M.D. New York, Paul B. Hoeber, Inc., 1937. $5.50.

In the preface, Dr. Albee states that in compiling the material for the book he included all procedures, conservative and operative, which he uses, as well as certain procedures which he does not use but which are commonly employed by surgeons of experience and mature judgment. He states that the bibliography is selective and usable rather than complete. The author quotes directly from the published articles of other writers when he presents their methods. This has the merit of accuracy, although it is perhaps rather tedious for the average reader. The author is quite frank in his frequent claims for priority in a number of procedures, but priority is a matter of record and is uninteresting and unimportant to readers.

There is very little that one can actually criticize in the book when it is [illegible]

that it is fundamentally a monograph based upon the author's *personal experience*. In fact this personal phase gives the book its value, for no man living today has done more than Dr. Albee to advance bone surgery. Accordingly, his chapter on armamentarium of the surgeon for hip work is interesting and instructive.

Albee advises the use of the autogenous bone peg rather than the Smith-Petersen nail in recent fractures of the neck of the femur. For old ununited fractures he advocates thorough removal of the fibrous tissue between the fragments, thorough freshening and fitting of bone surfaces, and insertion of an autogenous bone peg. For cases of long standing with much erosion of fragments and malnourishment of the capital fragment, Albee advises strongly his reconstruction operation. This operation consists of two steps: First, the head of the femur is excised and the remnant of the neck is smoothed down and inserted in the acetabulum; second, osteotomes are driven from above downward through the trochanter vertically to pry outward a good-sized piece of the trochanter (a greenstick fracture), and between it and the major portion of the trochanter the denuded and freshened head is inserted to act as a fulcrum. This piece of trochanter thus pried outward provides a lever to which the trochanteric muscles are attached. Albee lays great stress on this lever action and uses the same principle in his arthroplasties, the fulcrum being provided by pieces of bone from the iliac wall wedged into the trochanteric cleft.

For congenital dislocations of the hip he prefers closed reduction and sees no necessity for open procedures except in older children and in the more resistant cases. He favors arthrodesis for tuberculosis of the hip in adults and outlines several types of operations. First, where destruction is moderate and the neck long, he advises an extra-articular bone graft taken from the tibia or the upper end of the femur. Second, where destruction is greater and the trochanter is approximated to the ilium, he advises taking the graft from the iliac wall or using the trochanter, somewhat after the manner of Hibbs. For children, conservatism should be adhered to. (One wonders why the word "echor" is used instead of abscess. It is little known to American readers.)

Other conditions—synovitis, arthritis, ankylosis, coxa vara, osteo-arthritis, etc.—are dealt with in the same interesting personal way. The book is readable and one that every orthopaedic surgeon will be interested in. The author and Dr. Preston who assisted him are to be congratulated in giving us an interesting book on a field of surgery about which little has been written.

This book of 298 pages, beautifully printed on fine paper, is a credit to the publisher.

La spondylolyse et ses conséquences. Spondylolisthésis—scoliose listhésique. Pierre Glorieux et Carle Roederer. Paris, Masson et C^ie^, 1937. 60 fr.

The authors have presented this subject under the term of spondylolysis, which includes any solution of continuity in the posterior vertebral area, but which has too often been regarded as confined only to spondylolisthesis.

The authors have gone into the subject of the etiology with especial thoroughness by the consideration of the anatomical factors and their relation to the etiology. They point out the large area in which these anatomical variations or defects may be distributed, and it is shown that this condition in reality occupies a much larger field than that which is usually covered by writers on this subject.

Among the complications which the authors have considered, spondylolisthesis has special attention, but the varieties and areas of the different displacements are also treated in detail, and it is of value to have these grouped in the general discussion of this one subject, for as a rule they are not given sufficient prominence. It is shown that these displacements may be due either to a congenital anomaly or to a lesion.

The chapter dealing with the clinical and roentgenographic diagnosis the reader will find full of practical and valuable information. The clinical symptoms and the physical examination give the first evidence of the existence of the abnormalities, which must be later confirmed and the exact localization determined by the roentgenogram. The

portion of the book dealing with the roentgenographic diagnosis is most carefully and completely presented, and the interpretation of the shadows, with their significance, is discussed in a thorough and clear manner. The roentgenograms are nearly all accompanied by very excellent line drawings illustrating the anatomical position of the defects. The detection of the anatomical conditions by roentgenograms taken at different angles has also been given prominence; this is a feature of much importance for frequently these defects can be detected by the use of anteroposterior or lateral rays. All of this is necessary, for the interpretation of the shadows is particularly difficult, and the important part they play in diagnosis makes essential such a treatment of this part of the subject.

A chapter is then devoted to that form of scoliosis which has its origin in this condition, *"scoliose listhésique"*, and many examples of the variations found in this type are given.

The chapter on treatment covers the field fully,—first the cases which do not need treatment are discussed and then the conservative and operative methods are considered. The object and limitations of the conservative treatment are given necessary importance. The operative measures receive more space, and all the various operative methods are explained, including operations on the anterior portion of the spine.

The book is copiously illustrated by excellent roentgenograms, of which a large number are accompanied by line drawings of the structures which are shown. The book is evidently the result of long study and is full of practical information.

Sportschäden und Sportverletzungen (Accidents and Injuries from Sports). Prof. Dr. Burghard Breitner. (Neue Deutsche Chirurgie, LVIII.) Stuttgart, Ferdinand Enke, 1937. 16 marks.

This 173-page book is written by the head of the surgical clinic in the center of Europe's most active winter-sport region. Breitner gives an introductory review of the historical development of athletics and their philosophical significance. Athletics should aim at the performance which is best for the individual and not at maximal accomplishment of the human machine. Properly supervised sport has no hazards peculiar to it, and statistical surveys show the occurrence of accidents to be relatively infrequent. About 75 per cent. of all ski injuries occur among beginners; accidents decrease as the factors of intention and execution become correlated. The greatest single cause of athletic injury is a feeling of fear or underconfidence.

The major part of the book is devoted to the injuries common to each of the various branches of sport, from walking to flying (the chemical content of an exploding golf ball is not omitted!); and injuries are then discussed in their classification by anatomical location. This is followed by a section on the treatment of the more frequent injuries.

Breitner's book surveys a broad field and is based on an extensive bibliography. It is a comprehensive review of the subject of athletic injuries, written in a flowing, lucid style, at the same time emphasizing many essential points. The sections of the book are subdivided under clear titles and the numerous references given in each section are valuable guides to the study of the various topics included.

Fracturas y luxaciones. Terencio Gioia. Tomo II. Buenos Aires, Aniceto Lopez, 1934.

In this second volume, a book of 670 pages, Prof. Gioia has presented a very thorough discussion of the subject of fractures and dislocations of the cranium, the face, and the spine. The subject of fractures and dislocations of the extremities will be considered in Volume III soon to be published.

In discussing the fractures and dislocations which occur in each of these three regions, the author considers the manner of occurrence, the etiology, the diagnosis, and the treatment. The many varieties of fracture of the skull, the method of occurrence (including gunshot wounds), and the treatment are especially well presented. He also discusses

the sequelae of the trauma which may cause serious complications that are difficult to treat, and this adds very definitely to the practical value of the work. The operative procedures, particularly those used in the first and second regions, are given sufficient prominence, and the different steps of the operations are illustrated by excellent photographs and drawings, some of which are in color. Fractures and dislocations of the spine, both singly and combined, are dealt with in the last section. There are excellent line drawings to help in the interpretation of the x-ray shadows. The conservative treatment of fractures of the spine is also emphasized, and methods of correction and retention are well described and illustrated.

Volume III of this series should be most welcome.

HOFFA-GOCHT TECHNIK DER MASSAGE. Doz. Dr. Hans Storck. 9 Aufl. Stuttgart, Ferdinand Enke, 1937. 8.60 marks.

This volume of 123 pages, originally written by Hoffa-Gocht, appears in its ninth revised edition from the pen of Dr. Hans Storck of the Orthopaedic Clinic of Berlin University. The technique of massage is ably and clearly discussed. The description of the various methods is similar to that found in American text-books. In the preface, and even more in the chapter on the physiological effects of massage, the present author faces his most difficult problem,—a discussion of the scientific basis for massage and a description in physiological terms of the effects which it produces. The experimental data are well presented but they are not adequate. One feels that here is a field for study and research that would give much worth-while data which could be applied in physiotherapeutic medicine.

The various procedures are well illustrated by good line drawings. A number of anatomical plates to illustrate the massage of various groups of muscles are also given. The general arrangement of the book is commendable. The subjects follow each other in logical sequence, and the author describes as lucidly as is possible methods of treatment which can be learned only by example. It should prove to be a useful reference book for physicians and physiotherapists as well as a supplementary text-book for students.

THE TECHNIC OF LOCAL ANESTHESIA. Arthur E. Hertzler, A.M., M.D., Ph.D., LL.D., F.A.C.S. Ed. 6. St. Louis, The C. V. Mosby Company, 1937. $5.00.

The sixth edition of Hertzler's work on local anaesthesia comes to hand in a well-printed volume with 142 illustrations which should assist the would-be employer of the techniques in selecting sites for the introduction of needles to anaesthetize practically any region of the body where local methods are at all applicable.

After a short discussion of the best drugs to employ, their limits of usefulness, and the methods of administration, there follow a few pages on minor operations, such as the opening of abscesses, the removal of tumors (circumscribed benign, infiltrating localized, and malignant), the search for foreign bodies, skin grafting and the suturing of wounds.

From Chapter IV to the section on spinal anaesthesia, the subject is treated regionally. Certain operations in the abdomen are included within the field of local anaesthesia, although the author would, in general, restrict operations upon the viscera to spinal anaesthesia, paravertebral and splanchnic methods having been replaced by spinal anaesthesia. Nerve blocking in the case of the sacral nerves is given a few pages of description, but the author feels that the chance of hitting all the sacral foramina is quite problematic. Spinal anaesthesia is fully described and its complications are considered. Then follows a discussion of local infiltration anaesthesia for herniae; for operations upon the external genitalia, the bladder, the prostate; for repair work on the female genitalia; for hemorrhoids and fistulae; and, finally, for the minor amputations on the hand and foot,—hallux valgus and ingrowing toenails.

It may be that all this can be accomplished with the ease and general surgical satisfaction that the author would seem to have experienced, but it is notable in reading the

text that there is a frequently recurring admonition to the effect that if the operator does not feel that he has sufficient mastery of the technique to undertake a given operation as described, he had best resort to some other method.

Die Drahtextension. Anleitung zum praktischen Gebrauch. (Wire Extension. A Guide to Practical Use.) Prof. Dr. Rudolph Klapp und Dr. W. Rückert. Stuttgart, Ferdinand Enke, 1937. 15.80 marks.

As a successor to nail extension, wire traction has been developed through many refinements. This monograph presents the modern technique, including choice of wire, shape of the point, type of guide, and fixation device. Lateral traction by use of a cannula or by beaded or threaded wire is emphasized. A chart of sites of insertion is given. Pitfalls and complications are enumerated.

The application of the method to individual topographically arranged fractures is illustrated by photographs, roentgenograms, and many excellent diagrams. The technique is given also for the treatment of contractures, subluxations, and complicated wounds by wire traction.

This compact manual of 144 pages with 185 well-labeled illustrations is a pictorial exposition of the subject elaborated by well-chosen paragraphs which are subheaded for greater ease of reading. It is a practical and most valuable addition to the subject of skeletal traction.

A Textbook of Surgical Nursing. Henry S. Brookes, Jr., M.D. St. Louis, The C. V. Mosby Company, 1937. $3.50.

There are many features to commend this book as a guide for the nurse interested in surgical nursing. Possibly there is an undue amount of space given to the descriptions and illustrations of operations and surgical conditions which are the particular concern of the surgeon. This is, of course, interesting and helpful to the nurse, but one wishes that more might have been said of the actual place of the nurse in the work.

The first part of the book contains the kind of material needed for the teaching of student nurses,—the discussion of inflammation and infections; the various kinds of burns, wounds and tumors; and the preparation of dressings and bandages. The chapter on preoperative and postoperative care—perhaps the most important phase of surgical nursing—is well done as is also the chapter on postoperative complications. One would also commend particularly the chapter on fractures and dislocations. The care of the various types of orthopaedic cases requires good intelligent nursing quite as much as—perhaps more than—the usual postoperative cases, both because of the length of the illness and because of the mental condition of the patient who is more or less helpless for a long period. Nursing of these cases is surely the test of a good nurse, and requires careful instruction and supervision on the part of those who are teaching student nurses. Much helpful information on the nursing care of such cases is included in this book.

Some of the procedures described in the chapter on special procedures could be omitted from this particular text, inasmuch as they may be included in medical as well as in surgical nursing, and should be taught the young student early in her course before she is able to carry out the more advanced specialized techniques. The same might be said of some of the diets described. Although the glossary repeats terms already familiar to the student nurse or available to her in her medical dictionary, the words are well selected in relation to this text and deserve the special emphasis here given.

Among the outstanding features of the book are the illustrations which are unusually good and very well selected.

Short-Wave Diathermy. Tibor de Cholnoky. New York, Columbia University Press, 1937. $4.00.

Short-wave diathermy has been so generally employed in recent years that an authoritative discussion of the way it has been studied and brought to its present state of reliability is very timely. This book represents a study of more than 700 articles appear-

ing in the literature of the past eight years, including the experimental work that has been done by a great number of research students, physicists, and electrotherapeutists. It is a thoroughly critical review and leaves the impression that the author has approached his task *in an unbiased attitude*.

As the author points out, there is still so much to be learned in respect to tissue resistance—the specificity of certain wave lengths for certain types of tissue and the changes in tissue resistance to the passage of short waves, depending upon the pathology of the tissues to be treated—that one cannot be too positive in one's claims for the value of the method. What can be stated with some degree of finality is that to date the beneficial effects that may be attributed to its use are due to heat and that in the hands of a specialist it is the best way of applying heat locally to deep-seated tissues. Of the various types of lesions where it has proved most efficacious, the inflammatory lesions (acute, subacute, and chronic) are the best prospects for relief. It is a worth-while book for anyone who wishes to make intelligent use of this type of physiotherapy.

The Journal wishes to acknowledge the receipt of the following publications sent to the Editorial Department:

Acta Paediatrica, XIX, Fasc. 1, 2, and 3, Supplementum I, 1936–1937.
Anales de la Facultad de Ciencias Medicas de la Plata (Buenos Aires), I, 1937.
Annaes Paulistas de Medicina e Cirurgia (São Paulo), XXXIII, No. 5, 1937.
Archivos de la Sociedad de Cirujanos de Hospital (Santiago de Chile), VII, Nos. 1, 2, and 3, 1937.
Bethesda (Pittsburgh, Penna.), XXXIX, No. 3, 1937.
Boletim Clinico e de Estatistica dos Hospitais Civis de Lisboa (Lisbon), I, No. 1, 1937.
Boletim da Secretaria Geral de Saude e Assistencia (Rio de Janeiro), II, Num. 4, 1936.
Boletin del Centro Antirreumatico (Buenos Aires), I, Num. 1, 1937.
Boletin de los Hospitales (Caracas), XXXV, No. 9, 1937.
Boletines de la Sociedad de Cirugía de Rosario, III, Nos. 7 and 8, 1936.
Bollettino e Atti della Reale Accademia Medica di Roma, LXIII, Fasc. 1–4, 1937.
Bulletin of the National Tuberculosis Association, XXIII, Nos. 8 and 9, 1937.
The Child (Washington, D. C.), I, 1936–1937; II, Nos. 1 and 2, 1937.
*Chronic Rheumatic Diseases, Being the Third Annual Report of the British Committee on Chronic Rheumatic Diseases Appointed by the Royal College of Physicians. Edited by C. W. Buckley, M.D., F.R.C.P. New York, The Macmillan Company, 1937.
Cirurgía y Cirujanos (Mexico, D.F.), V, Núm. 5, 1937.
Cleveland Clinic Quarterly, IV, Nos. 2 and 3, 1937.
Current Medicine, IV, Nos. 6 and 8, 1937.
Health Shoes, II, No. 10, 1937.
Hospital for Joint Diseases of the City of New York. Thirtieth Annual Report for the Year 1936. New York, 1937.
The Johns Hopkins University Circular. School of Hygiene and Public Health, Catalogue Number 1937–1938. Baltimore, 1937.
Mundo Medico (Rio de Janeiro), XI, Nums. 495–501, 1937.
Radiography and Clinical Photography, XIII, Nos. 2 and 3, 1937.
Revista de Cirugia Hospital Juarez (Mexico, D.F.), VIII, Num. 7, 1937.
Roche Review, I, Nos. 8, 9, 10, 11, and 12, 1937.
Roma y Moscu. Impresiones de un Cirujano Argentino. Prof. Lelio Zeno. Rosario, Talleres Gráficos "Fenner", 1937.
Tissue Reactions in Bone and Dentine. A Morpho-Biological Study of the Formation and the Dissolving of Bone and Dentine. Åke Wilton, M.D. London, Henry Kimpton, 1937.

* To be reviewed in a subsequent issue.

University of Chicago Medical Schools. Announcements for the Sessions of 1937–1938, XXXVII, No. 14, 1937.

Upsala Läkareförenings förhandlingar, XLII, Häft. 1–6, 1936–1937.

Verzeichnis der Ärztekurse im Studienjahre 1937–1938. Das Kursbüro der Wiener Medizinischen Fakultät. Vienna, 1937.

TEN OPERATED CASES OF INJURIES TO THE CRUCIAL LIGAMENTS IN THE KNEE JOINT. Ivar Palmer. *Acta Chirurgica Scandinavica*, LXXIX, 391, 1937.

Ruptured cruciate ligaments probably do not heal spontaneously. The writer advocates early suture with silk. He reports six operations in such recent cases of injury. Of these patients, one died of embolism, but five showed complete or almost complete restitution to normal motion with a negative "drawer" sign. Four chronic cases were operated upon, and a graft of tendon or fascia was inserted. Two patients were symptom-free, one was improved, and in one the knee was stable but much reduced in motion as the result of a second operation. The writer calls attention to the relative magnitude of the late operation. It is contra-indicated when the collateral ligaments are damaged or when there are secondary degenerative joint changes.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

INSERTION OF SMITH-PETERSEN NAIL FOR INTRACAPSULAR FRACTURES OF NECK OF FEMUR. J. Albert Key. *American Journal of Surgery*, XXXVI, 466, May 1937.

The author has attempted to simplify the method of introduction of the nail by avoiding complicated apparatus. The fracture is reduced by the Leadbetter method, which assures accuracy of the reduction. Check-up roentgenograms of both the anteroposterior and lateral views are taken. Local anaesthesia of 1-per-cent. novocain is used in combination with either avertin or morphine. A six-inch incision is made over the lateral surface of the femur from the tip of the trochanter. A drill, described as a three-sixteenths-inch twist drill, carpenter's type, six inches long, is inserted about three inches. The angle and depth are then checked by a second series of roentgenograms. The nail is selected and driven into place along the drill hole, after removal of the drill, or higher or lower than the position of the drill, as the case may be, so as to penetrate the head and neck a little below the midline. The distal fragment is firmly impacted upon the head, and the position checked with a third series of roentgenograms. No postoperative fixation is used. Slight overreduction is preferable. Weight-bearing is allowed one month after operation, but crutches are used for at least three months.—*Custis Lee Hall, M.D., Washington, D. C.*

CORKSCREW-BOLT FOR COMPRESSION-FIXATION OF FEMORAL NECK FRACTURES. Robert K. Lippmann. *American Journal of Surgery*, XXXVII, 79, July 1937.

Six cases of intracapsular fracture are reported and indicate that accurate insertion can be accomplished by roentgenographic or fluoroscopic control. The device is a corkscrew of reduced pitch, with four turns, devised to hold the capital fragment, the diameter being three-eighths to one-half an inch. No preliminary drilling is done and no wires are used. The author claims mechanical efficiency in holding cancellous bone. At the end of the bolt are threads, with a trochanter catch for impacting the fracture. The middle portions of the bolt are smooth. This mechanism also prevents rotation of the instrument, the catch being impacted into the trochanter and held tightly by a nut on the shaft. Hip reduction was by the Leadbetter method and a small incision below the trochanter was used to reach the shaft of the femur. No postoperative fixation was used except in the first cases. Function and stability shortly after operation indicate that security of fixation may be as dependable as bony union long before union is possible. The corkscrew bolt of the author is markedly similar to a threaded bolt used at the *Istituto Rizzoli* by Putti, and now in the developmental stage.—*Custis Lee Hall, M.D., Washington, D. C.*

CLINICAL OSTEOMYELITIS OF LONG BONES. Rodney F. Atsatt. *American Journal of Surgery*, XXXVII, 291, August 1937.

The author discusses four types of osteomyelitis,—the simple, delayed, chronic, and septic. Six cases illustrating these types are given in detail, with a description of both the radical and conservative methods used. Supportive measures were intravenous fluids, metaphen, and prontylin, supplemented with blood transfusions where indicated. There was one fatal case in the septic group. Postoperative treatment consisted of the usual Orr vaselin pack and plaster fixation.—*Custis Lee Hall, M.D., Washington, D. C.*

TRAUMATIC SEPARATION OF EPIPHYSIS OF LOWER END OF FEMUR. Harold Bellin. *American Journal of Surgery*, XXXVII, 306, August 1937.

After a review of the literature, which includes more than 200 cases, the author reports one case. He calls attention to the need for roentgenographic examination in order to make accurate diagnosis of this injury. Reduction was easily accomplished by acute flexion of the knee which was maintained until healing and followed by extension manipulation. The end result, four years later, indicates a crepitation in the joint, thickening of the epiphysis, knock-knee tendency, with a lengthening of the leg of one inch.—*Custis Lee Hall, M.D., Washington, D. C.*

SHORT NOTES ON ARTHRITIS. B. B. Battacharjee. *The Antispetic*, XXXIV, 468, 1937.

The author presents a series of brief notes on his experience in the treatment of arthritis, which he classifies under twelve etiological types. He notes that the pneumonic type of arthritis affects the upper extremities more than the lower, and larger joints more than smaller ones. Consideration is given chiefly to gonorrhoeal arthritis, in the treatment of which the author apparently relies on potassium iodide, sodium salicilate, acid sodium phosphate, morphine, and injections of fresh sterilized milk.—*Robert M. Green, M.D., Boston, Massachusetts.*

PAINFUL COCCYX. George A. Duncan. *Archives of Surgery*, XXXIV, 1088, June 1937.

After a brief survey of the history, anatomy, and etiology of coccygodynia, the author considers the various theories for this pain. He then discusses the clinical course and treatment of painful coccyx based on a study of 278 patients seen in the New York Orthopaedic Dispensary and Hospital. He is of the opinion that trauma is the explanation for most of these incidences and that the diagnosis of neurasthenia "is an admission of defeat on the part of the physician". In general the injection treatment has been found unsatisfactory. Postural correction, local heat, and local massage constituted the usual non-operative therapeutic methods, and gave relief to a very large percentage of the patients. He advocates conservative therapy for six months before operative resection is resorted to. Coccygectomy resulted in complete relief from coccygeal pain in only 74 per cent. of the cases, but this procedure is recommended when conservative treatment has failed. The article contains a good statistical analysis.—*I. William Nachlas, M.D., Baltimore, Maryland.*

ANOMALIE SCHELETRICHE SINGOLARI IN UN FETO OTTIMESTRE (Unique Skeletal Anomalies in an Eight-Months-Old Foetus). Riccardo Galeazzi. *Archivio di Ortopedia*, LII, 369, 1936.

A stillborn female foetus at the end of the eighth month revealed skeletal anomalies which have not been described in the literature. The main feature was the abnormal shortness of the extremities. Ossification had occurred only in the radii, the tibiae, and the terminal phalanges of the fingers and the toes. All of the other bones had remained

cartilaginous without any trace of osteogenesis. The base of the skull was likewise underdeveloped and entirely cartilaginous. Only three vertebral bodies of the thoracolumbar junction showed small centers of ossification; the bones with membranous origin, however, were normally developed. Galeazzi traces the origin of the anomaly to the earliest stages of embryonic life. The pathogenesis is obscure, but Galeazzi suspects an alteration of the precartilaginous blastema and believes that such anomalies belong to the group of phocomelia.—*Ernst Freund, M.D., Los Angeles, California.*

L'Artrorisi nella cura della deformità talocrurale congenita di Volkmann (Arthroereisis in the Treatment of Volkmann's Congenital Ankle Deformity). Riccardo Galeazzi. *Archivio di Ortopedica*, LII, 391, 1936.

Volkmann's deformity may be due to an underdevelopment of the fibula, or to a backward displacement of the outer malleolus, or to a combination of both factors. In all such cases, Galeazzi uses a corrective procedure which consists mainly of an arthroereisis of the ankle joint, in which the fibula is used as a bone block. The outer malleolus is brought into its physiological position, or the fibula is osteotomized and the lower fragment is displaced downward and forward to form a normal external malleolus. In the more severe case, in which the child has walked for several years with the foot in a position of marked valgus, changes occur in the joint line of the tibiotarsal articulation. Galeazzi performs an osteotomy of the tibia above the joint, brings the lower joint end into correct alignment, and fills the resulting defect with bone taken from the tibia at a higher level. Illustrations show the satisfactory results obtained with the operative procedure.—*Ernst Freund, M.D., Los Angeles, California.*

L'Osteotomia curvilinea a cerniera nella cura di diverse deformità ossee ed articolari (The Curved Hinge Osteotomy in the Treatment of Various Deformities of Bones and Joints). Luigi de Gaetano. *Archivio di Ortopedia*, LII, 405, 1936.

Gaetano thinks that this form of osteotomy has not found the wide application which it deserves. The osteotomy can be performed with a special saw (Alessandri) or with curved and straight chisels. The advantages which this operation has over straight and wedge-shaped osteotomies are emphasized and the different parts of the skeleton to which the procedure can be applied are discussed. Rachitic deformities of the long bones are the main indication. Knee-joint deformities rank next, usually necessitating supracondylar osteotomies.—*Ernst Freund, M.D., Los Angeles, California.*

Considerazioni sopra un caso di malformazione congenita della mano (A Case of Congenital Malformation of the Hand). Giulio Cardi. *Archivio di Ortopedia*, LII, 427, 1936.

The author reports a case of a male, sixteen years of age, with a family history of finger anomalies. Examination showed a deformed left hand with syndactylism of the first phalanges of the third and fourth fingers which had a common third metacarpal. The fourth metacarpal bone was hypoplastic. Cardi believes that such deformities are due to an arrest of or an aberration in the growth of the embryonic tags from which the extremities later develop.—*Ernst Freund, M.D., Los Angeles, California.*

Un caso raro di emimelia (A Rare Case of Hemimelia). Annunziato Caratozzolo. *Archivio di Ortopedia*, LII, 435, 1936.

The author reports the case of a seven-year-old girl with a short stump of a forearm. At the end of the stump were four small fingers without a skeleton, merely cutaneous appendages. The thumb was absent.—*Ernst Freund, M.D., Los Angeles, California.*

Contributo allo studio dell'osteogenesi imperfecta (Contribution to the Study of Osteogenesis Imperfecta). L. Racugno. *Archivio di Ortopedia*, LII, 441, 1936.

Following a review of the literature on etiology, pathogenesis, and physiopathology of osteogenesis imperfecta, two cases are reported, one of which was hereditary. The differential diagnosis and treatment are discussed.—*Ernst Freund, M.D., Los Angeles, California.*

Sulle fratture della colonna vertebrale (con particolare riguardo alla diagnosi radiologica, alla evoluzione ed agli esiti a distanza). [Fracture of the Vertebral Column (with Particular Regard to the Roentgenographic Diagnosis, the Course, and the End Result).] Carlo Schapira. *Archivio di Ortopedia*, LII, 465, 1936.

This long and interesting article gives a statistical report on 105 cases of fracture of the spine observed at the *Istituto Ortopedico Toscano* from 1926 to 1936. The more interesting cases are discussed in detail, especially those of fracture of the cervical spine and of the odontoid process, and the end results are given. The roentgenographic picture of fracture of the thoracic spine is discussed in detail, and the differential diagnosis is considered. Attention is paid to the behavior of the intervertebral discs in cases of fracture of the vertebral bodies, and cases are mentioned in which severe trauma to the spine was followed only by rupture of the vertebral disc. The problem of the unrecognized fracture of the spine is considered, and the important question concerning localized deforming spondylarthritis and fracture of the vertebral body is answered with the assumption that localized hypertrophic changes are due to callus formation rather than to arthritis. Kümmel's traumatic spondylitis has not been observed by the author. He thinks that such cases are either unrecognized fractures of the vertebral body or quite often cases of Pott's disease. As far as treatment is concerned, Schapira advocates Böhler's active treatment with reduction and exercises, but discusses also at length the method of Magnus.—*Ernst Freund, M.D., Los Angeles, California.*

Fixation of the Hip-Joint by Means of an Extra-Articular Bone-Graft: Late Results. Hugh C. Trumble. *The British Journal of Surgery*, XXIV, 728, 1937.

This is a report of cases operated on by a method described in 1932, in which a bone graft is placed between the ischium and the shaft of the femur, below the level of the lesser trochanter. The operation was carried out on eight patients with tuberculous hip joints. The grafts united satisfactorily in seven patients. In three instances sinuses to the hip joint healed after the fusion. There was no primary or secondary sepsis in the operative wounds. Fracture of the graft occurred in one case eighteen months after operation.

The Treatment of Fractured Patella by Excision. A Study of Morphology and Function. R. Brooke. *The British Journal of Surgery*, XXIV, 733, 1937.

Complete removal of the patella as a treatment for fracture of the patella is recommended. This is certainly radical treatment, but the author produces results that warrant the new method.

From the standpoint of comparative anatomy it is evident that the patella is a vestigeal structure and that function does not influence its development and growth. In slowly moving animals the patella is massive and well developed, while in rapidly moving animals it is small. Developmentally, the bone forms behind the quadriceps tendon and becomes attached to it secondarily, but it does not develop within the tendon.

Experimental work on the cadaver, with the patella in place and then removed, has been carried out. By a system of pulleys and recording drums it has been shown that extension of the lower leg through a right angle took place more rapidly without the patella and that there was less resistance to a weight applied against the moving force.

The writer has removed the patellar fragments *in toto* from thirty patients. He does not give results on all his cases, but in ten instances he has made end-result studies

which show, with one exception, that the injured member is stronger in resisting flexion than the uninjured one. Recovery takes place in two to three weeks and laboring men return to ladder-climbing in six weeks.

The operation is done forty-eight hours after injury. The bone fragments are shelled out through a vertical incision. The article is illustrated by photographs of patients following operation.

A Note on the Extension Apparatus of the Knee-Joint. Ernest W. Hey Groves. *The British Journal of Surgery*, XXIV, 747, 1937.

Hey Groves states that he has personally examined eight of Brooke's patients and feels that all claims made for the operation are justified. He has made anatomical studies which convince him that the quadriceps tendon merely passes over the patella. He believes that in operating on a fractured patella the important part of the operation is the suture of the lateral expansions of the quadriceps tendon. He is convinced that when the patella is removed a much closer and firmer repair of the torn tendon can be made.

Psychological Factors in Rheumatism. A Preliminary Study. James L. Halliday. *British Medical Journal*, I, 213, 264; 1937.

The author presents a regional analysis of the part played by psychological factors in bringing about such symptoms as pain, stiffness and limitation of movement. He emphasizes that these symptoms, in the absence of organic change, are often erroneously called rheumatism or fibrositis, neuritis, sciatica, lumbago, and so forth, and are commonly treated by physical therapy. Frequently the illness in which the symptoms emerge is much better understood and treated by regarding the complaint as a manifestation of a chronic psychoneurotic state in which the "rheumatism" occurs merely as an episode. This is based upon behavior patterns or instincts which drive the individual to behave as a human being. The conflict of these instincts with the individual's environment may provoke a reaction of illness which belongs to two groups: First, environmental factors which the individual meets by direct contact of his body tissue; second, those factors which frustrate or threaten to frustrate the instincts that drive the individual. Physicians can greatly increase their understanding of illness by realizing that when the instincts are frustrated emotion is manifested. By means of this mechanism, psychological factors may profoundly affect the individual. With the passage of time, the bodily disturbances resulting from emotional reaction may subside, or one or more of the disturbances may be maintained in the original or modified form. For example, in the respiratory system, choking and sobs may merge into asthma, while in the locomotor system, the soreness and stiffness which the patient may have experienced between paroxysms of grief is translated into "rheumatism". Pain may be an expression of inferiority, inherited or acquired. Acquired inferiority may be physical, or mental in the form of knowledge and fear.

The author considers in some detail how a particular site may be chosen for pain. This is usually due to the fact that the patient considers a particular body site as "inferior", either in a physical or in a mental state; or else a symptom may be attached to a part of the body by a mechanism known as symbolization. For example, pain in the low back in the absence of structural change may mean that the individual's pride has been hurt, as exhibited in persons who through unemployment are compelled to take up an occupation which is beneath them. This point is further developed by histories of patients who have suffered from "rheumatism", with inability to move a joint, but who have shown no organic lesion.

In his discussion of prevention and treatment, the writer stresses the fact that adequate therapy depends on recognition of the true nature of the patient's disorder and on knowing how not to make the patient worse. Such recognition requires a thorough physical examination, an appreciation of the part which psychological factors play in affecting the body, and, finally, the refraining from discovering structural [illegible]

which are not there. The knowledge of how not to injure the patient necessitates an understanding of the three main characteristics of psychoneurotic illness, — innocence and rationalization, increased suggestibility, and motive and purpose.

This is an excellent paper. It is well worth detailed study.—*G. E. Haggart, M.D., Boston, Massachusetts.*

La maladie de Köhler du scaphoïde tarsien (Köhler's Disease of the Tarsal Scaphoid). Willy Smets. *Bulletin de la Société Belge d'Orthopédie*, VII, 65, 1936.

From a clinical study and a survey of the literature, Smets (Brussels) believes that the so-called Köhler's disease of the tarsal scaphoid is simply a normal variation in ossification. This conclusion is based on the following observations: (1) The lesion is usually bilateral; (2) there are no clinical signs in the majority of cases and it is simply an incidental roentgenographic finding; (3) so-called healing occurs spontaneously; (4) one can usually find alterations in ossification of a similar nature in other parts of the body; (5) there is a familial tendency to this abnormality, which is shown particularly well in twins, a fact observed by Camerer. At times, as the author shows in a case described in detail, this "paranormal ossification" is a generalized phenomenon.—*John J. Kuhns, M.D., Boston, Massachusetts.*

Syndrome héréditaire (Hereditary Syndrome). R. Montant et A. Eggermann. *La Presse Médicale*, XLV, 770, 1937.

The authors give the general history of a family in which ten instances of a hereditary disease were observed. The condition is characterized by hypoplasia of the patella and malformation of the head of the radius, which leads to dislocation of the head of the radius and limitation of pronation and supination, with a hemiatrophy of the cubital half of the thumbnail. The symptoms are found only in blonde, blue-eyed individuals, though not all the blonde, blue-eyed individuals are affected. The condition is apparently dominant; it is not sex-linked, and, because of its preponderance, is believed to be due to a single gene.—*Henry Milch, M.D., New York, N. Y.*

La maladie de Pellegrini-Stieda (Pellegrini-Stieda Disease). L. Sabadini. *La Presse Médicale*, XLV, 797, 1937.

The author is of the opinion that Pellegrini-Stieda disease is a true molecular fracture at the femoral attachment of the tibial ligament. Even in those cases where roentgenograms taken immediately after the alleged injury show no gross fragments, the author believes that the fracture is still present, but so small as not to show on the print. He believes the symptoms are due invariably to tension on the tibial collateral ligament during the action of flexion, hyperadduction, and external rotation of the leg. In its first phase, the condition is characterized by localized tenderness and localized swelling at the epicondyle of the femur. Stiffness and interference with flexion are present, but there is never any intra-articular fluid. A roentgenogram taken in this first stage often shows a paracondylar shadow. Following the acute injury there is a latent period during which the patient complains of a slight limp, and pain on flexion. Then, gradually and progressively, the third stage, the so-called characteristic Pellegrini-Stieda disease, is initiated by pain, functional limitation, especially flexion, and gradual development of a paracondylar osteoma.

In the first stage, treatment consists of rest, immobilization on a plaster splint and local infiltration with novocain. Massage is, of course, completely contra-indicated. In the later stage, operative intervention for the removal of the calcific mass may be undertaken, provided repeated roentgenograms show that the process of calcification has reached the end stage.—*Henry Milch, M.D., New York, N. Y.*

ROENTGENTHÉRAPIE DE L'ARTHRITE BLENNORRAGIQUE (Roentgenotherapy of Gonorrhoeal Arthritis). Nguyen-Dinh-Hoang. *La Presse Médicale*, XLV, 895, 1937.

Nine cases of gonorrhoeal arthritis, involving various joints of the body, are reported. All seem to show definite relief from pain after roentgenotherapy. The author is of the opinion that this treatment is indicated both in the acute and in the chronic phases of the disease. Even in the frankly purulent forms, the severity of the affliction may be minimized by the use of x-ray therapy. In the acute cases, the dosage should be lower than in the chronic cases. Details of the technique are furnished in the article. In the acute and subacute stages careful judgment must be used to avoid lighting up the process. The author believes that as a result of stimulation of phagocytosis, bactericidal action, proteolysis, stimulation of the circulation and modification of the pH, roentgenotherapy permits amelioration of the pain, with earlier and more complete restoration of function.

—*Henry Milch, M.D., New York, N. Y.*

DES DOULEURS PROVOQUÉES PAR L'EXCITATION DU BOUT CENTRAL DES GRANDS SPLANCHNIQUES (Reflex Pains from Stimulation of the Central Ends of the Cut Splanchnic Nerves). René Leriche. *La Presse Médicale*, XLV, 971, June 30, 1937.

During the course of the past few years twenty-one sections of the splanchnic nerve have been performed for different indications. Usually these operations have been performed under general anaesthesia, but, recently, the author has been using spinal anaesthesia. In two such cases, while the greater splanchnic nerves were being cut slowly, the patient suddenly complained of severe pain in the thoracic region. When the left splanchnic was cut, the patient complained of pain in the cremasteric region; when the right was cut, in the pulmonary region. This pain was immediately relieved by injection of novocain into the cut nerves. On the basis of these observations the author suggests that anginal pain noted after a heavy meal may be reflex and circulatory in nature and connected with irritation of the splanchnic nerves.

The communication is extremely interesting and stimulating, and offers new vistas for clinical observation.—*Henry Milch, M.D., New York, N. Y.*

RESTAURATION DU POUCE PAR POLLICISATION DU DEUXIÈME MÉTACARPIEN (Restoration of the Thumb by "Pollicisation" of the Second Metacarpal). Marc Iselin et Jean Murat. *La Presse Médicale*, XLV, 1099, July 28, 1937.

The authors call attention to the fact that the efforts at restoration of the thumb may be divided in general into two types: First, the so-called methods of phalangization, recommended by the French school, and, second, the methods of reconstruction of the thumb by grafting, recommended by the Austrian school. The authors favor utilization of the second, in place of the first metacarpal. In principle, the operation consists of maintenance of the nervous, vascular, and muscular structures of the second finger, while at the same time placing the finger in the position of opposition. This is done mainly by osteotomy of the metacarpal, but involves, as auxiliary problems, the making of the web, the treatment of the stump of the injured thumb, etc.

The details of this operation are not described, since they are to appear in a forthcoming article.

A number of very interesting photographs, illustrating the end results, are presented, as well as the outlines of two case histories.—*Henry Milch, M.D., New York, N. Y.*

ÉTUDE STATISTIQUE SUR L'ÉTIOLOGIE DE LA MÉNINGITE TUBERCULEUSE (Statistical Study of the Etiology of Tuberculous Meningitis). Pierre Nobécourt et Sotirios B. Briskas. *La Presse Médicale*, XLV, 1131, August 4, 1937.

Following their larger studies on the appearance of tuberculosis in children, recently published, the authors interested themselves in the study of tuberculous meningitis. Of 13,331 children up to the age of fourteen years and eleven months, seen between the years 1921 and 1925, 311 cases, or 2.5 per cent., were found to have tuberculous meningitis.

Tuberculous meningitis is seen infrequently between the ages of three and twelve months; never seen before three months, and reaches its maximum frequency of over 6 per cent. at about the age of five years, after which it gradually declines. It attacks boys and girls equally and seems to appear more commonly in the spring and summer than in the fall. This probably represents not a true seasonal variation, but a variation dependent upon the number of children hospitalized during the respective months.—*Henry Milch, M.D., New York, N. Y.*

TECHNIQUE SIMPLIFIÉE POUR L'ARTHRODÈSE EXTRA-ARTICULAIRE DE LA HANCHE PAR GREFFON TIBIAL DANS LA COXALGIE TYPE 37 (Simplified Technique for Extra-Arthrodesis of the Hip by Means of Tibial Graft). H. L. Rocher. *Journal de Médecine de Bordeaux et du Sud-Ouest*, CXIV, 69, 1937.

The author recommends a modification of Massart's type of arthrodesis of the hip. The typical anterior Smith-Petersen incision is made and then a longitudinal external lateral incision is made over the greater trochanter. A hole is drilled over the base of the greater trochanter, emerging at the upper surface of the neck. The capsule is not opened. A bed is gouged in the side of the ilium, and a tibial graft is passed through the drilled hole in the trochanter and buried in the ilium. The limb is then immobilized in plaster.

The author calls this arthrodesis "Type 37" and recommends it particularly for extra-articular fusions in cases of tuberculosis.—*Henry Milch, M.D., New York, N Y.*

HEREDITARY MULTIPLE ANKYLOSING ARTHROPATHY (Congenital Stiffness of the Finger Joints). A. R. Bloom. *Radiology*, XXIX, 166, 1937.

Investigation of the various cases reported proves that this anomaly is inherited according to Mendel's law. There is never ankylosis at birth. It starts in childhood and early youth, and becomes more marked as the subject grows older. At any one time various stages can be seen in various joints, up to solid bony union. The fingers are never alone involved, the condition commonly affecting also metatarsals, head of the radius, and lumbar vertebrae. One case is reported. In this case practically all the tarsal bones were fused into one solid mass.—*Edward N. Reed, M.D., Santa Monica, California.*

THE END RESULTS OF INJURIES TO THE EPIPHYSES. Oscar Lipschultz. *Radiology*, XXVIII, 223, 1937.

This paper attempts to answer the question, "Does premature ossification or deformity result from traumatic displacement of epiphyses?" One hundred and six cases of such epiphyseal displacement were followed up for from sixteen months to eight years, the epiphyses involved being those at the lower end of the radius, ulna, tibia, and fibula, the upper end of the humerus, the medial epicondyle, lateral epicondyle, and lesser trochanter of the femur.

Premature ossification, with changes in growth, took place in 14 per cent. of the cases. While the amount of shortening is usually minimal, it is occasionally marked, resulting in deformity and disturbance of function.

Perfect reduction does not ensure against marked interference with growth, nor is failure of reduction necessarily followed by marked disturbance.—*Edward N. Reed, M.D., Santa Monica, California.*

FRACTURE DISLOCATION OF THE UPPER END OF THE HUMERUS. Guy W. Leadbetter. *Southern Medical Journal*, XXX, 433, April 1937.

This is a report on seventeen cases. Such fracture-dislocations usually occur after severe trauma which may be caused by automobile accidents or falls from a height. Two of the cases were treated satisfactorily by suspension traction, with gentle manipula-

tion from day to day. Ten cases were reduced, with fluoroscopic control, by means of strong traction and digital manipulation. Five cases were treated by open operation; in one of these the head was completely removed and a weak, unsatisfactory shoulder resulted. Two of these patients died, both were syphilitics. Plaster fixation was usually used after reduction except in traction cases. The author found that in the cases reduced by manipulation the results were better, and the patients remained in the hospital a shorter time. Open operation is difficult and causes considerable trauma and permanent damage to the joint. Early reduction is important. Even a week of delay increases the difficulty of reduction.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

Adamantinoma of the Tibia. E. L. Bishop. *Southern Medical Journal*, XXX, 571, June 1937.

Adamantinoma is the specific tumor arising from the enamel of the teeth. Extramaxillary adamantinomata are rare. The case which the author describes is believed to be the fifth case so far reported,—three in foreign literature, and now two in this country. The tumor occurred in the upper end of the tibia. One and a half years previously, the patient had sustained a fracture in this region. On removal of the cast, eight weeks later, there was a swelling in this area, but he was able to go hunting. Roentgenographic examination showed a multilocular cystic area which was diagnosed as a multiple bone cyst or giant-cell tumor. The area was curetted and filled with bone chips and two tibial grafts. The diagnosis of material removed was "adenocarcinoma". Sixteen months later, roentgenograms showed that there was absorption of bone chips and graft, and that the tumor had involved the soft tissues. Amputation was performed. Sections from many areas of the tissue showed typical structure of adamantinoma. There has been no recurrence or metastasis.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

Arthrodesis of the Knee with a Large Central Autogenous Bone Peg. J. Albert Key. *Southern Medical Journal*, XXX, 574, June 1937.

In this operation, after removal of the cartilaginous surfaces of the tibia and femur, a large graft is removed from the crest of the tibia through a separate incision. This graft is driven up into the shaft of the femur between the condyles for about two inches, then wedged into the upper end of the tibia for about the same distance. The tibia and femur are then forced together, the wound is closed, and a plaster spica is applied. The advantages claimed are that the peg stabilizes the knee while plaster is being applied, prevents motion between the bones, and hastens firm bony ankylosis. It is not used in children because injury to the epiphyses would prevent growth.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

Venous Stasis Accelerates Bone Repair. Herman E. Pearse, Jr., and John J. Morton. *Surgery*, I, 106, Jan. 1937.

As Key and Walton had questioned their previously published experimental evidence, Pearse and Morton repeated their work on the effect of venous stasis on bone repair. In twenty-eight experiments, in which bilateral resection of three to four millimeters of dogs' fibulae was performed, repair was found to be accelerated on the side of ligation of the popliteal vein in 90 per cent. of the cases. They reviewed the experimental evidence as presented by other authors and concluded that venous stasis does accelerate bone repair.

Ununited Fracture of the Neck of the Femur. Willis C. Campbell. *Surgery*, I, 499, Apr. 1937.

After discussing the various theories as to the cause of non-union of fractures of the neck of the femur, the pathology was reviewed. The author feels that [illegible]

rect, and that in some instances the head is viable, in others it is dead and acts as a sequestrum. The treatment depends on various factors, including the age and general condition of the patient and the viability of the head of the femur. He reports seventy-five cases in which some operative work has been done for non-union. In thirty-six of them, a tibial bone graft was used, with solid union resulting in twenty cases. There was one death among these patients, and eight operations were considered failures. Results in seven cases are not known, or it is too early for the final results to be determined. This operation he considers the ideal procedure, as perfect anatomical restoration is possible.

In thirty-five cases in which some type of reconstruction operation was performed (Whitman, Albee, Brackett, or a modification of these), there were fourteen with excellent results; eight were failures; there was one death; and in twelve the result is unknown.

Osteotomy was done in four cases. In one there was an excellent result; the others are too recent to estimate.

ZUR WIEDERHERSTELLUNGS-CHIRURGIE DES KNIEGELENKES (Restorative Surgery of the Knee Joint). Arnold Wittek. *Wiener klinische Wochenschrift*, L, 803, 1937.

This article presents several outstanding points derived from a survey of over 1100 operations on the knee joint in a country where winter sports and football make the subject one of constant general interest. Sudden hyperextension of the knee in skiing may stretch or tear the anterior cruciate ligament and permit not only anterior displacement of the tibia on the femur but also an abnormal lateral mobility in the manner of a genu valgum. Few such injuries ever heal by immobilization in a cast; conservative treatment may succeed only when there is overstretching and not avulsion of the ligament. Healing of the torn ligament depends on the integrity of an artery that enters it from the popliteal space. Therefore, Wittek bases his operations on the restoration of blood supply from this source. Although there sometimes occurs spontaneous reformation of previously destroyed cruciate ligaments, one way in which he achieves this revascularization is to unite the intact posterior cruciate ligament to an attached tibial fragment of the anterior ligament.

In cases in which the medial meniscus is loosened also, Wittek substitutes the meniscus for the anterior cruciate ligament by attaching its posterior end to the posterior cruciate ligament after additional fixation of the anteromedial rim of the meniscus to the cartilage of the medial tibial condyle. The anterior end of the medial meniscus may also be drawn through an artificial intercondylar tibial canal. When a strip of patellar tendon is used similarly, the lower end of the strip retains its continuity with the rest of the patellar tendon.

Where there is injury to the cruciate ligament combined with injury to the medial lateral ligament, Wittek exposes the joint by chiseling off a portion of the medial femoral epicondyle and turning it down with a triangular portion of the capsule. After repair of the internal ligaments the separated epicondyle is nailed into a new bed proximal to its original position. This effectively restores the support lost by the stretching and laceration of the medial lateral ligament.

Such operations assume serious responsibility on the surgeon's part and are to be undertaken only after unsuccessful trial of conservative measures or when operation is definitely indicated. Although danger of occasional infection exists, Wittek reports a series of 600 operations on cruciate and meniscus ligaments without a single instance of infection.—*O. Theodore Roberg, Jr., M.D., Chicago, Illinois.*

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